Environment and Development in Bangladesh

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Volume One

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PREFACE

Bangladesh is faced with rampant poverty, high population density and an increasing population, recurring natural disasters and a dwindling natural resource base. Furthermore, there are geomorphological and political instabilities, high level of dependence on foreign aid and donor domination in decision-making. Bangladesh is also in the formative stages of democracy and formation of democratic institutions. All these factors make it imperative to integrate environment in all developmental concerns taking place in Bangladesh.

Economic emancipation of the ever-growing population of Bangladesh is the objective for any development practitioner. However, given the current scenario in Bangladesh which BCAS has defined as a *Sub-subsistence Economy and Stressed Ecological System*, the only mode of practical development is sustainable development i.e. integrating environment and development issues. This book is a preliminary attempt to achieve this.

Environment and Development in Bangladesh has its origins in the activities and concerns of the Bangladesh Centre for Advanced Studies (BCAS) and the Norwegian Agency for International Development (NORAD) who jointly organized a seminar on "Environment and Development" in May 1989 in Dhaka. Many of the most prominent scientists and policy planners of Bangladesh presented papers on a wide range of issues relating to environment and development in Bangladesh.

After the seminar, a number of other areas were identified and incorporated to present a more comprehensive book. In the aftermath of the floods of 1987 and 1988, the Flood Action Plan (FAP) was conceived. No other project, in the history of Bangladesh, will affect the environment more should the major components of FAP be implemented. We have, therefore, included several chapters which address the potential development and environmental impacts of the FAP.

From an academic viewpoint, it is a challenging task to focus on the interrelationship between environment and development. The methods and analytical concepts of one particular discipline will not be adequate to address the complex relationships which exist between ecological processes and human activities. In order to comprehend these relationships, an interdisciplinary approach is needed. The editors of this book had initially ambitions in attempting to discuss ways in which an interdisciplinary

approach could be developed. We encouraged all authors of the various chapters to go beyond their respective disciplines and link their topic to the related development processes in their field. We admit that we have succeeded in our efforts only to a very limited extent. In this process, we have, however, learnt how difficult it is to have scientists addressing issues which are interdisciplinary in character. One of the major intellectual challenges in Bangladesh in the coming years will be to enhance the understanding of the complex relationship between environment and development.

Despite these limitations of the book, we have, nevertheless, decided to publish it. In recent years many reports and books focusing on various environmental issues have appeared in Bangladesh. The book before you, we believe, is the first which addresses all the major fields of environmental concerns. The book will therefore serve the purpose of providing an overview of important issues which will have to be dealt with in the future development of Bangladesh.

The preparation of the book has occurred over a period of several years so some of the earlier chapters may appear rather dated. However, we have chosen to retain them to allow all the relevent aspects to be covered within these two volumes. A number of authors suggested that we use an existing paper of theirs which reviewed the subject matter in a manner we could use. We have therefore included some previously published papers (with due acknowledgement) in order to make the book more comprehensive. We hope that despite these acknowledge limitations readers will find useful to have all the chapters together in one set of volumes.

CHAPTER ONE

ENVIRONMENT AND DEVELOPMENT LINKAGES IN BANGLADESH

A. Atiq Rahman and Saleemul Huq

Bangladesh is one of the poorest of the developing countries with a low resource base, a very low land-man ratio, threatened by both natural hazards and anthropogenic mismanagement and over-exploitation. The vast majority of the population is amongst the poorest in the world and live almost exclusively on the natural resource base. But this resource base is under serious threat and environmental planning is necessary to signal any hope for survival with dignity and sustainability.

Problems, Paradoxes and Opportunities

The current situation of environmental management in Bangladesh is one of :ransition, opportunity, uncertainty and perhaps paradox. Conditions remain among the most difficult in the world in which to develop effective and mplementable environmental policy and effective regulations, for a set of nterrelated reasons. The most important amongst these are:

Mass Poverty

The people need income and employment now, even if it means resource nining or heavily polluting actions. Though the poor are often the victims of environmental degradation and mismanagement, they may have to participate in irriversible processes to eke out a living.

Immense Pressures

Extremely high population density exerts tremendous pressures on the natural resources which are rendered precarious by hazards such as recurring floods, river erosion, cyclones etc.

Low Resource Availability

Lack of internal resources retards investment in remedial and other environment-enhancing investment, e.g. for industrial pollution, upgrading of water supply or sanitation. The greatest resource, the people, is hardly mobilized anywhere near optimal to environmentally sound social and development processes, though some interesting initiatives are being undertaken, particularly by the non-government sectors.

Institutional Weakness

Administrative capability in environment is generally weak and overburdened. Bangladesh has a fair number of environmental laws but the level of observance and enforcement capability is very low. The bureaucracy, for an environmentally sound development agenda, will have to be pro-people and pro-active. The existing bureaucracy, in many cases, still resembles an earlier colonial model.

Poor Information Base

Bangladesh has a literacy rate of less than thirty per cent. Very few government agencies or even universities have the capability to address environmental issues with a sufficient degree of competence. Though recently more discussions are being undertaken, lack of systematic data on natural resource systems is a hindrance to develop proper environmentally sound development options.

Large Projects

These are still being undertaken with little or no consideration to the environment. People's participation is very often missing. Lip service given to environment and people's participation can be misleading and may distort genuine attempts to improve projects toward sustainability.

However, there are some signs of change, with an increase in activities relating to the environment, particularly, in the last few years. These include:

Political Commitment

At the political level, there has been an expressed commitment to the environment, even if it is yet to find a clear direction.

Government Initiatives

At the official level, a new Ministry of Environment and Forests and an upgraded Department of Environment have been formed. A National Conservation Strategy exists, an Environmental Policy has been finalized and a National Environment Management Action Plan (NEMAP), however inadequate, is in the pipeline. Their implementation is awaited and some concerns have been expressed as to the limited scope and lack of an effective public discussions on these.

Donor Agency Interest

Among the donor agencies who finance most development projects, there is increasing interest and thus potential, for technical assistance for the environment and some capital support. But most donor agencies are limited by their hang-ups and need to push money quickly and often the initiatives are from their headquarters.

Expert Manpower

There is a sizable expert manpower in the country, though very little specifically in environmental science; this manpower can be mobilized to address environmental issues. Some non-government research organizations are giving leadership in its area.

Increasing NGO Activities

There is growing expertise and emergence of effective non-government organizations and advocacy groups who are raising environmental issues and developing data bases on natural resources and evaluating people's perceptions on the environment.

Indigenous Knowledge Base

The poverty stricken rural population has a tradition of frugal practices and indigenous knowledge which are often environmentally sound. Their documentation is scanty but examples are many.

The Development Challenge for Bangladesh

Despite the adaptations and resourcefulness of the people of Bangladesh, the overall economic and development statistics for the country are daunting. A per capita average annual income was just \$160 in 1986 and \$220 in 1992. Tables 1 to 6 is a summary presentation of the economic, human resources, poverty and child related indicators which can be considered as measures of the development and environmental stress; hence the challenge. The tables compare Bangladesh with neighbouring countries and typical middle income and developed countries. As 80 per cent of the people living below the poverty line, government policy is understandably oriented towards poverty alleviation as an overriding development objective. Sixty per cent of Bangladeshi households are without sufficient land to produce enough food for their families. Twenty per cent of Bangladeshi households do not even have enough land for a homestead.

Some 60 per cent of the total land area is cultivated, one of the highest percentages in Asia. Agriculture represented slightly less than half of the GDP in 1986, and average annual rate of growth in agricultural production was about 2.7 per cent from 1980-1986, which was barely enough to keep pace with population growth. In 1992 the country was for the first time self-sufficient in rice, the main staple diet. Food shortages affect more than half the population and food imports were rising to keep abreast of demand. Export volumes are relatively small and not well diversified. However, in 1992 food (grain) self sufficiently was attained, thanks to a disaster-free year. This has reduced the price of rice, the key commodity for the farmers, in the market, thus exposing the agricultural farmers to another vulnerability of the market price of their produce.

Access to clean water is problematic for many households and as a result of contaminated drinking water, gastro-enteritis and other water-borne diseases are common. The effect of these diseases, together with chronic malnutrition and inadequate health services is a high rate of infant mortality; 25 per cent of infants die before the age of 5. Maternal mortality rates are nearly 100 times greater than the rates for Scandinavian countries.

Table 1

Economic Indicators

Low Income Economies (of South Asia)	Population (Millions) mid. 1991	GNP per capita (Dollars) 1991	Average annual growth rate (%) 1980-1991	Average annual rate of inflation (per cent) 1980-91	Average Annual Growth rate (per cent)				
					GDP 1980-91	Agriculture 1980-91 equivalent), 1991	Industry 1980-91	Manufacturing 1980-91	Service etc. 1980-91
Bangladesh	110.6	220	1.9	9.3	4.3	2.7	4.9	2.9	5.6
India	886.5	330	3.2	8.2	5.4	3.2	6.3	6.7	6.7
Pakistan	115.8	400	3.2	7.0	6.1	4.2	7.5	7.8	6.6
Nepal	19.4	180	2.1	9.1	—	4.9	—	—	—
Sri Lanka	17.2	500	2.5	11.2	4.0	2.3	4.7	6.3	4.6
Bhutan	1.5	180	—	8.4	7.6	4.8	14.8	15.2	7.3

Source: World Development Report, 1993.

Table 1(Continued)

Economic Indicators

Countries	Population (Millions) mid. 1991	GNP per capita (Dollars) 1991	Average annual growth rate (%) 1980-1991	Average annual rate of inflation (per cent) 1980-91	Average Annual Growth rate (per cent)				
					GDP 1980-91	Agriculture 1980-91 equivalent), 1991	Industry 1980-91	Manufacturing 1980-91	Service etc. 1980-91
Middle Income Economies									
Brazil	151.4	2940	0.5	327.6	2.5	2.6	1.7	1.7	3.2
Malaysia	18.2	2520	2.9	1.7	5.7	3.7	7.7	9.6	4.7
Philippines	62.9	730	–1.2	14.6	1.1	1.1	–0.5	0.4	2.8
Thailand	57.2	1570	5.9	3.7	7.9	3.8	9.6	9.4	8.0
High Income Economies									
Japan	123.9	26930	3.6	1.5	4.2	1.2	4.9	5.6	3.7
U.S.A.	252.7	22240	1.7	4.2	2.6	—	—	—	—
U.K.	57.6	16550	2.6	5.8	2.9	—	—	—	—

Table 1(Continued)

Economic Indicators

Low Income Economies (of South Asia)	Avg. Annual Growth rate (%)		Energy consumption per capita (kg of oil equivalent 1991	Current account Balance (millions of Dollars)		Gross international Reserves (millions of Dollars) 1991
	Energy production 1980-91	Energy consumption 1980-91		After official Transfers 1991	Before official transfers 1991	
Bangladesh	11.3	7.7	57	–210	–932	1308
India	6.6	7.2	337	–3026	–3477	7616
Pakistan	6.5	6.5	243	–1558	–2171	1220
Nepal	10.9	8.0	22	–320	–380	451
Sri Lanka	8.5	4.9	177	–268	–472	724
Bhutan	—	—	15	17	–36	99

Table 1(Continued)

Economic Indicators

Countries	Avg. Annual Growth rate (%)		Energy consumption per capita (kg of oil equivalent 1991	Current account Balance (millions of Dollars)		Gross international Reserves (millions of Dollars) 1991
	Energy production 1980-91	Energy consumption 1980-91		After official Transfers 1991	Before official transfers 1991	
Middle Income Economies						
Brazil	7.3	4.7	908	-3071	-3071	8749
Malaysia	13.5	7.9	1066	-4530	-4617	11717
Philippines	6.3	1.9	218	-1034	-1388	4436
Thailand	24.1	7.4	438	-7564	-7609	18393
High Income Economies						
Japan	3.9	2.2	3552	72905	84740	80626
U.S.A.	0.7	1.4	7681	-3690	-24670	159273
U.K.	0.4	0.7	3688	-11438	-9575	48373

Table 2
Human Development Index (HDI)

HDI Status of Countries	Life expectancy at birth (years)	Adult Literacy rate (as % of age 15)			Literacy rate (as % of age 15-19)	Mean years of schooling (25 +)		
		Total	Male	Female		Total	Male	Female
	1990	1990	1990	1990	1990	1990	1990	1990
HIGH HUMAN DEVELOPMENT								
Hong Kong	77.3	—	—	—	—	7	8.6	5.4
Korea, Rep. of	70.1	96	99	94	100	8.8	11	6.7
Argentina	71	95	96	95	97	8.7	8.5	8.9
MEDIUM HUMAN DEVELOPMENT								
Malaysia	70.1	78	87	70	94	5.3	5.6	5
Brazil	65.6	81	83	80	92	3.9	4	3.8
Thailand	66.1	93	95	91	99	3.8	4.3	3.3
Philippines	64.2	90	90	90	96	7.4	7.8	7
LOW HUMAN DEVELOPMENT								
Maldives	62.5	—	—	—	—	4.5	5.1	3.9
Pakistan	57.7	35	47	21	50	1.9	3	0.7
India	59.1	48	62	34	66	2.4	3.5	1.2
Bangladesh	51.8	35	47	22	46	2	3.1	0.9
Nepal	52.22	26	38	13	39	2.1	3.2	1
Bhutan	48.9	38	—	—	0.2	0.3	0.1	0.51

Source: Human Development Report, UNDP, 1993.

Table 2 (continued)
Human Development Index (HDI)

	Educational Attainment 1990	Population with access to Health Services (%) 1987-90	Safe Water (%) 1988-90	Sanitation (%) 1988-90	Daily calorie supply (as % of requirements) 1988-90	Human development index 1900
HIGH HUMAN DEVELOPMENT						
Hong Kong	2.34	—	100	—	125	0.913
Korea, Rep. of	2.65	100	78	99	120	0.872
Argentina	2.61	—	—	89	131	0.832
MEDIUM HUMAN DEVELOPMENT						
Malaysia	1.92	88	78	94	120	0.79
Brazil	1.87	—	96	78	114	0.73
Thailand	2.16	59	72	62	103	0.715
Philippines	—	—	81	70	104	0.603
LOW HUMAN DEVELOPMENT						
Maldives	2.26	75	70	28	80	0.497
Pakistan	0.55	85	50	22	99	0.311
India	0.93	—	75	13	101	0.309
Bangladesh	0.58	74	78	122	88	0.189
Nepal	0.35	0.35	37	6	100	0.17
Bhutan	0.51	80	34	—	128	0.15

Table 3
Trends in Human Development

Countries	Life expectancy at birth years		Infant mortality per 1000 live birth		Population with access to safe water %		Daily calorie supply as % of requirements	
	1960	1990	1960	1990	1975-80	1988-90	1965	1988-90
LOW HUMAN DEVELOPMENT COUNTRIES								
Bangladesh	39.6	51.8	156	111	—	—	91	88
India	44	59.1	165	90	31	75	89	101
Pakistan	43.1	57.7	163	101	25	50	76	99
Maldives	43.6	62.5	158	58	—	—	—	—
Nepal	38.3	52.2	187	102	8	37	87	100
Bhutan	37.3	48.9	203	133	—	—	—	—
MEDIUM HUMAN DEVELOPMENT COUNTRIES								
Malaysia	53.9	70.1	73	15	—	—	101	120
Philippines	52.8	64.2	80	42	—	—	82	104
Thailand	52.3	66.1	103	28	25	72	95	103
Brazil	54.6	65.6	116	59	62	96	100	114
HIGH HUMAN DEVELOPMENT COUNTRIES								
Hong Kong	66.2	77.3	44	6	99	100	—	—
Republic of Korea	53.9	70.1	85	222	66	78	96	120
Argentina	64.9	71	60	30	—	—	119	131

Source: Human Development Report, 1993, UNDP.

Table 3 (Continued)

Trends in Human Development

Countries	Adult literacy rate %		Combined primary and secondary enrolment ratio		Real GDP per capita PPP$	
	1970	1990	1970	1987-90	1960	1990
LOW HUMAN DEVELOPMENT COUNTRIES						
Bangladesh	24	35	37	42	621	872
India	34	48	49	68	617	1072
Pakistan	27	35	26	29	820	1862
Maldives	—	—	—	—	—	—
Nepal	13	26	19	60	584	920
Bhutan	—	—	4	18	—	—
MEDIUM HUMAN DEVELOPMENT COUNTRIES						
Malaysia	60	78	62	75	1783	6140
Philippines	83	90	85	97	1183	2303
Thailand	79	93	58	59	985	3586
Brazil	66	81	65	91	1404	4718
HIGH HUMAN DEVELOPMENT COUNTRIES						
Hong Kong	—	—	76	87	2323	15595
Republic of Korea	88	96	76	97	—	—
Argentina	93	95	81	96	3381	4295

Table 4
Progress Report of Bangladesh

Sl. No	Indicators	Bangladesh	Regional Average	World Average	Ranking	
					Total Country amongst Countries of South Asia	Rank
1.	Survival (Child Mortality 1991 : per 1000)	133	131	97	6	4
2.	Nutrition (Child Malnutrition)	66%	—	—	—	—
3.	Education (Children reaching grade : 5)	47%	50%	68%	6	3rd
4.	Family Planning (Average birth 1991, per woman)	4.8	4.4	3.4	6	3rd
5.	Progress for Woman (Maternal death per 100,000)	600	490	310	7	4th
6.	Health (Child vaccinated)	53%	79%	77%	7	6th

Source: The Progress of Nation, 1993, UNICEF.

Table 5
The Food Security Index for 15 Developing Countries

Country	Per capita daily calorie supply as a percentage of requirements		Percentage annual growth in per capita daily energy supply	Per capita food production index (1979-1981 = 100)	Food staples self sufficiency ratio	
	1965	1985	1965-1985	1966-1988	1965-1967	1986-1988
Bangladesh	85	78	0.42	92	97	98
Bhutan	126	107	0.79	118	83	86
Brazil	101	111	0.5	108	89	88
Chile	106	104	0.09	105	84	94
Ethiopia	79	73	0.36	89	101	90
India	95	96	0.06	105	90	99
Indonesia	83	115	1.63	117	99	95
Korea, Democratic People's Rep	100	133	1.46	111	94	96
Korea, Republic of	96	119	1.1	98	91	42
Maldives	75	88	0.79	117	29	15
Nepal	88	91	0.17	100	100	100
Pakistan	76	94	1.11	107	104	107
Philippines, The*	86	100	0.78	90	85	92
Sri Lanka	97	112	0.71	79	56	73
Thailand	99	108	0.43	101	146	144

Source: The state of the World Rural Poverty, IFAD, 1992.

Table 6

Profile of the Rural Poor in 15 Developing Countries

Country	Total population (000) 1988	Rural population: Number (000) 1988	Rural population: Percentage of total 1988	Agricultural population: Number population (000) 1988	Agricultural population: Percentage of total 1988	Rural population below poverty line: Number population (000) 1988	Rural population below poverty line: Percentage of rural 1988	Average rural household size (no.) 1984-1988	Dependency ratio (per cent) 1985
Bangladesh	109632	95503	87	76588	70	82133	86	5.6	95.4
Bhutan	1448	1278	88	1321	91	1150	90	4	76.5
Brazil	144428	35570	25	36994	26	25966	73	5.4	68.7
Chile	12748	1931	15	1730	14	1081	56	4.5	59.5
Ethiopia	44762	39239	88	33885	76	16873	43	6.2	101.2
India	819482	598614	73	520112	63	251418	42	4.4	72.1
Indonesia	175109	128179	73	80829	46	34608	27	4.7	7.3
Korea, Democratic people's Rep.	21895	7438	34	7735	35	1488	20	5.2	73.2
Korea, Republic of	42626	12963	30	10376	224	1426	11	5	52.1
Maldives	202	161	80	131	65	64	40	5.2	88.7
Nepal	18237	16632	91	16772	92	10146	61	5.5	82.7
Pakistan	115042	79331	69	62072	54	23006	29	6.6	90.1
Philippines. The*	59509	34985	59	28254	47	22390	64	5.9	80.2
Sri Lanka	16825	13264	79	8753	52	6101	46	5.6	63.3
Thailand	54160	42542	79	33529	62	14464	34	5.5	67

Source: The state of world rural poverty, IFAD 1992.

Table 6 (Continued)

Profile of the Rural Poor in 15 Developing Countries

Country	Percentage of rural population						
	Smallholder farmer population 1988	Landless population 1988	Nomadic pastoralist population 1988	Ethnic indigenous population 1988	Small and artisanal fishermen population 1988	Internally displaced refugee population 1988	Households headed by women as a percentage of rural households Mid-1980s
Bangladesh	63	20	—	1	6.4	—	16
Bhutan	76	—	—	—	—	—	17
Brazil	20	39	39	0.6	—	—	14
Chile	36	—	—	28.5	14	—	10
Ethiopia	78	16	—	—	—	4.6	55
India	47	30	—	5	1.3	—	15
Indonesia	59	15	—	—	13.1	—	20
Korea, Democratic People's Rep.	—	—	—	—	—	—	7
Korea, Republic of	81	4	—	—	2	—	15
Maldives	—	—	—	—	72	—	55
Nepal	66	18	—	—	0.9	—	15
Pakistan	17	30	2.4	—	1.1	4.5	9
Philippines, The*	40	34	—	—	16.8	0.6	12
Sri Lanka	64	22	—	—	7.4	3.4	20
Thailand	41	15	—	—	0.9	1	17

Despite relatively high growth rates for urban areas (over 10 per cent per annum), 85-90 per cent of the population still resides in rural areas. Because of the relatively high population growth rates (2.4 to 2.6 per cent per annum), a large proportion of the population is young and will soon greatly increase the ranks of those needing schooling and employment. Literacy rates are only 15-18 per cent for females and 25-35 per cent for males.

Population growth, in fact, is a constant factor in development planning in Bangladesh. The total population is now over 110 million, up from 90 million in 1981, and some 44 million in 1951. The population is expected to reach 140-145 million by the year 2000 and may not stabilize before exceeding some 240 million persons. Already, Bangladesh is the most densely populated country in the world, with the exception of city-states like Singapore. If the United States was as densely populated as Bangladesh, the entire population of the world would have to live within the borders of the U.S.

Main Environmental Issues and Problems

Population Growth

Bangladesh's population is about 110 million confined within 144,000 km^2, making its population density the highest in the world (Figure 1).

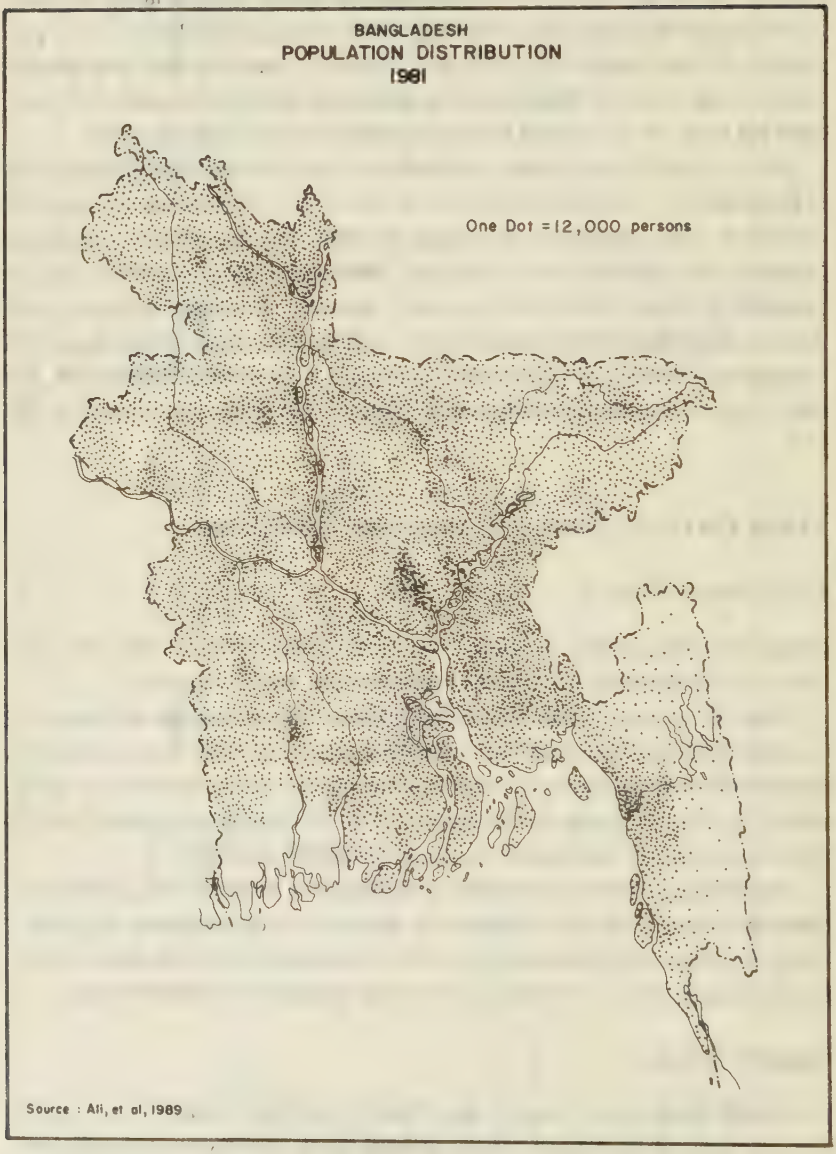
Over 50 per cent of the population is below 15 years of age and hence in the next 10 years, there will be a dramatic rise in demand for employment. Employment opportunities in agriculture appear to be limited and other sectors are not creating sufficient new jobs. The urban population was 13 million in 1981. It is expected to reach 41 million in 2000.

Population growth is identified as perhaps the most serious problem inhibiting a sustainable use of resources. Increases in development or productivity are eroded by population growth. A very low land/ man ratio intensifies the competition of the very limited land resources for different uses.

Natural Hazards

Recurrent floods cover large areas, often up to 30 per cent of the country. They affect and damage crops, seeds, trees, livestock, housing and infrastructure. Floods can enhance erosion by the rivers with consequent loss

Figure 1


BANGLADESH
POPULATION DISTRIBUTION
1981
One Dot = 12,000 persons
Source : Ali, et al, 1989

of valuable arable land. Areas hit by cyclones are not very large, but the devastation can be enormous. For example the cyclone of April 1991, killed an estimated 130,000 people. The north-west part of the country is vulnerable to drought and north-east to flash floods.

Agricultural Land

Data on the chemical composition of soils suggest a state of impoverishment. The low organic matter content, higher cropping intensity, improper cropping sequences and faulty management practices cause depletion of soil fertility.

There is an emphasis on increasing acreage under "High Yielding Varieties" (HYV) of rice, in many cases, displacing traditionally adapted and resistant varieties. The bias towards HYV rice increases agro-chemical use including both fertilizers and pesticides.

Water

The location of Bangladesh makes water management as the key issue in its environmental plans. Bangladesh is mostly a delta formed by sediments brought from the Himalayan drainage ecosystem and deposited along river banks and in the flood plains. Its coastal zone is extremely dynamic and at the inter-action zone where fresh water from precipitation and snow meets the saline sea water as shown in Figure 2. Position of Bangladesh in Himalayan drainage ecosystem is sown in Figure 3. There is an increase in the use of water for irrigation, often from ground water sources. There are indications of a lowering of the water table, due to indiscriminate use of ground water.

Shortages of water in river systems during the dry season are thought to be causing the saline belt to move northward. Withdrawal of water from the Ganges by India at Farakka Barrage has major impacts on lean-period water availability increased salinity and threatens ecosystems. Drought-prone areas are shown in Figure 4.

Water pollution, which is increasingly becoming a major problem may be categorized into three groups:

- *Faecal pollution* is widespread and has a strong negative impact on human health. Pollution continues unabated causing a number of water-borne diseases.

Figure 2

SCHEMATIC REPRESENTATION OF THE SITUATION OF BANGLADESH COASTAL ECOSYSTEM AT THE INTERACTION ZONE OF A FIGURE OF EIGHT

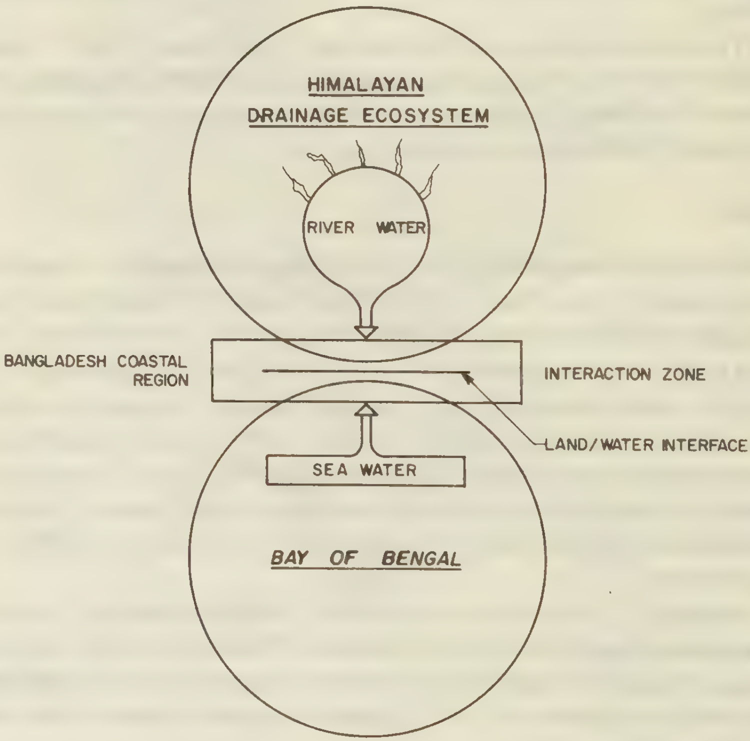


Figure 3

A TRANSECT OF THE HIMALAYAN FLOOD PLANE ECOSYSTEM (SCHEMATIC)

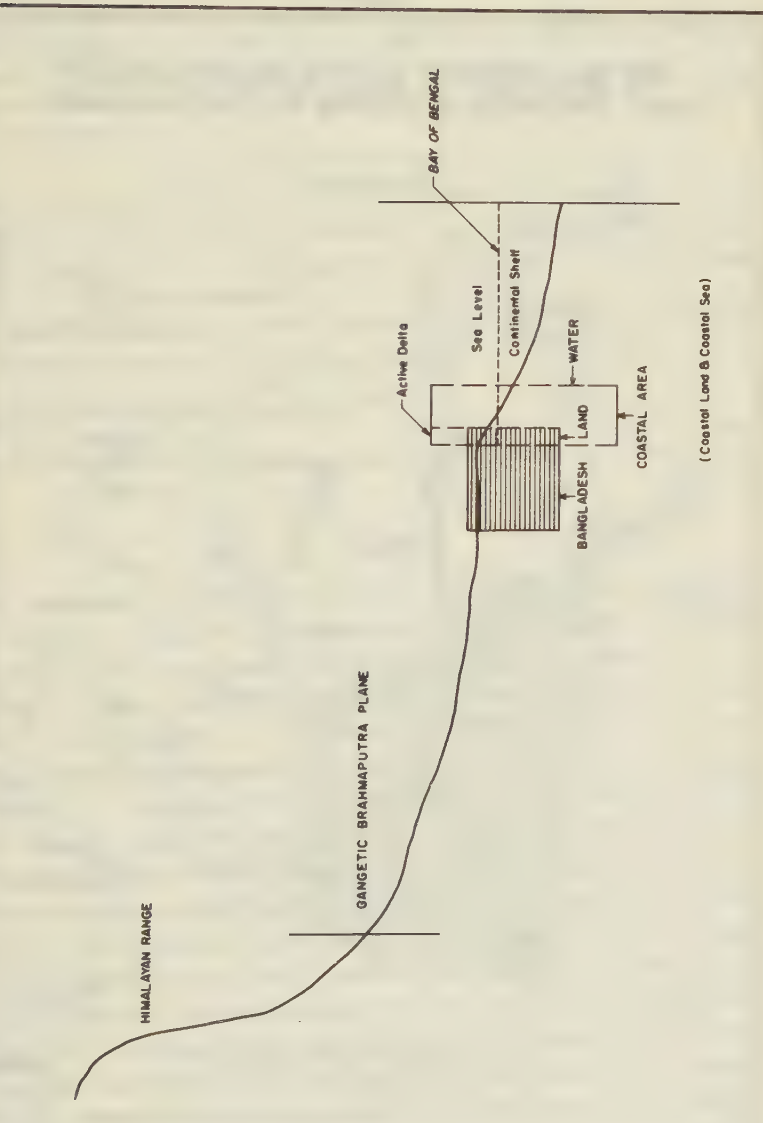


Figure 4


THE MAJOR RIVER SYSTEM IN BANGLADESH
AND THE AREA AFFECTED BY FARAKKA DAM
89°
90°
91°
92°
27°
26°
25°
24°
23°
22°
21°
20 0 20 40 60 Km.
Affected Area
INDIA
INDIA
INDIA
Rangpur
Dinajpur
Tista
Bogra
Jamuna
Atra
Rajshahi
Pabna
Padma
Kushtia
Garai
Mymensingh
Old Brahmaputra
Sylhet
Surma
Kushiyara
Tangail
Dhaka
Faridpur
Padma
Meghna
Comilla
Jessore
Madhumati
Khulna
Barisal
Patuakhali
Noakhali
Karnaphuli
Chittagong
Cox's Bazar
MYANMAR
BAY OF BENGAL
GEODESEC

- *Industrial pollution* is localized but untreated, industrial waste is dumped into rivers causing pollution of both the terrestrial and aquatic environments.
- *Agro-chemical pollution* is also feared as residues are expected to enter the food chain.

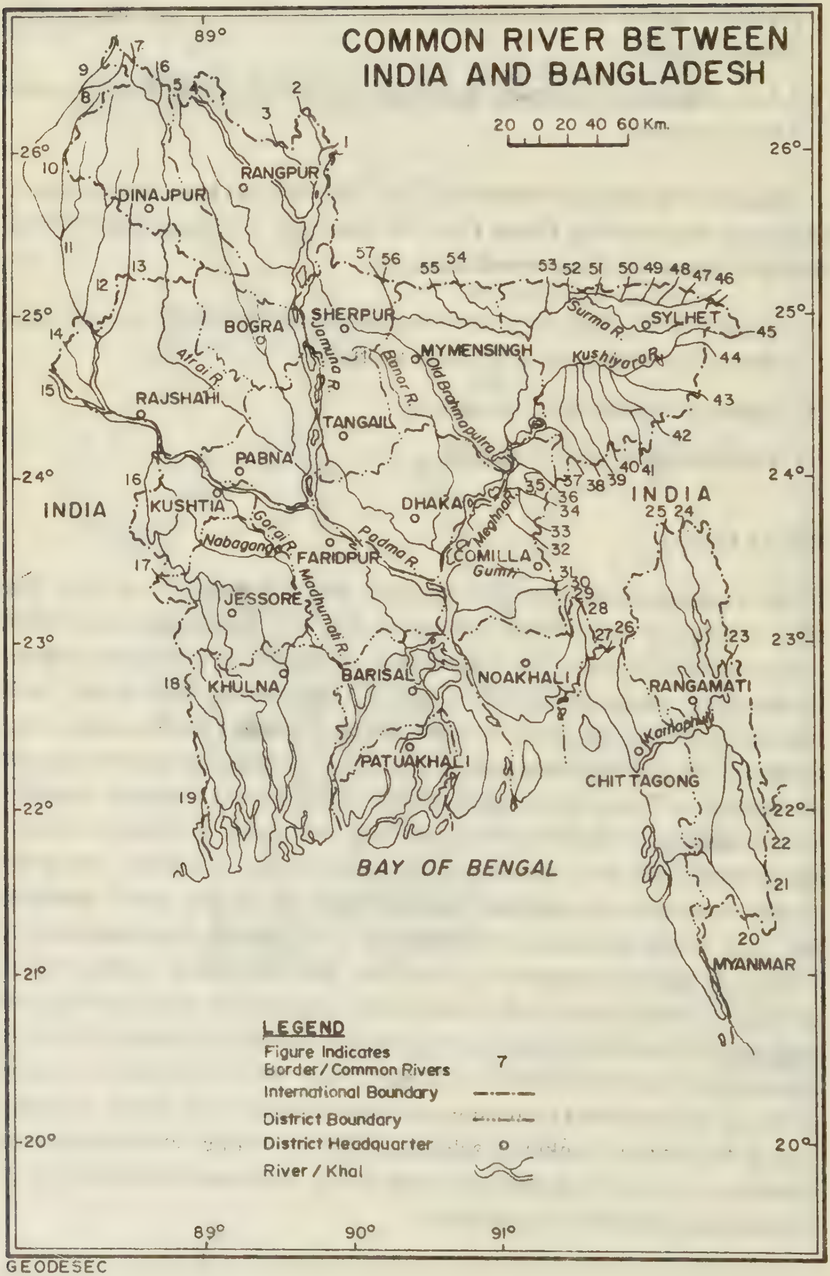
Though little detailed information was available, and more information is emerging the existing Flood Control Drainage and Irrigation (FCDI) structures appear to affect several areas e.g:

- Impact on fisheries by restricting migration, spawning grounds and decreasing flood plain availability for fish.
- Impact on inland water navigation.
- Increased siltation of river beds

Water Issues

Major water issues are also cross-sectoral, affecting almost all sectors. The river network in Bangladesh is shown in Figure 5. The major issues relate to dry season phenomena such as salinity encroachment in the coastal areas (particularly, the southwest) due to reduced and reducing river flows. These reduced flows are the result of construction of polders and embankments, increased and uncontrolled upstream extraction for irrigation and river beyond the borders of Bangladesh, particularly at the Farakka Barrage channel improvement. Increased and increasing low flow extraction clearly demonstrates the need for integrated water resource planning. The more surface water extracted upstream for land-based use, the less there is available for water-based uses such as fisheries and navigation. Encroachment of salinity in the dry season will continue. The removal of surface water reduces country wide fish production, encourages over fishing and exploitation possibilities and more rapid siltation of river beds will occur. The uncontrolled withdrawals of ground water have both led to a lowered ground water table and increasing salinity in certain areas. Water projects, such as the large embankment schemes, while protecting certain areas from flooding and improving drainage, have led to more rapid siltation of river channels and reduced fish production.

Figure 5


COMMON RIVER BETWEEN
INDIA AND BANGLADESH
20 0 20 40 60 Km.
89°
90°
91°
26°
25°
24°
23°
22°
21°
20°
DINAJPUR
RANGPUR
BOGRA
SHERPUR
MYMENSINGH
SYLHET
RAJSHAHI
TANGAIL
PABNA
KUSHTIA
DHAKA
FARIDPUR
COMILLA
JESSORE
KHULNA
BARISAL
NOAKHALI
RANGAMATI
PATUAKHALI
CHITTAGONG
INDIA
MYANMAR
BAY OF BENGAL
Atrai R.
Jamuna R.
Banar R.
Old Brahmaputra
Surma R.
Kushiyara R.
Meghna R.
Gorai R.
Nabaganga
Padma R.
Madhumati R.
Gumti
Karnaphuli
LEGEND
Figure Indicates Border/Common Rivers 7
International Boundary
District Boundary
District Headquarter
River / Khal
GEODESEC

Land Issues

Major environmental issues relating to land are cross-sectoral, in as much as, almost all sectors including, agriculture, water, forests, habitat, industry, horticulture compete for the use of it. Issues relating most directly to the resource are the continual erosion of old land by the rivers, the existing pattern of ownership of land, particularly, new land, and the low level of year round land utilization. The erosion of land has created increasing landlessness and potential over-exploitation of common resources such as fisheries and forests. New land which is often unconsolidated is highly underutilized because of ownership inequalities which stem from the existing power structure in the rural areas (particularly in the coastal areas).

Of major importance is the issue or need for a more integrated multi sectoral planning approach for land utilization and land reclamation. Of particular importance are the coastal land areas which are extremely vulnerable and currently the most underutilized. There is also a lack of collective management of water and land resources which has inhibited optimum sustainable utilization. In the final analysis, the land is in short supply and land remains the base of production and also to support the burgeoning population.

Natural Hazards

There are three major natural hazards affecting Bangladesh and of these, two could be aggravated by man-made degradation of the environment, both regionally and worldwide. The major hazards are increased flooding, cyclones and rising sea-levels worldwide due to global warming. The floods which occurred in Bangladesh in 1987 and 1988 were extremely severe and some of this severity is said to have arisen out of a reduction of forested land in the watershed, increased drainage congestion and flood plain area reduction upstream and in the delta. The increase of the sea-level, while still in the process cf being detected, could have a very severe impact on a delta area such as Bangladesh, should projected theoretical increases occur. The rise is suspected to be the result of increased greenhouse gases levels in the atmosphere due to increased fuel combustion worldwide amongst other reasons. Regional and worldwide environmental cooperation is required to affect any change in these issues and beyond the capacity of Bangladesh.

Cyclone appear to the recurrent and increasing in ferocity. The funnel shape of the Bay of Bengal (Figure 2) focuses many major cyclone to hit Bangladeshis coast. The last major cyclone April 1991 had a human toll of over 130,000 and devastating environmental impact.

Forestry

Commercial felling of timber for fuel and other uses together with encroachments for agricultural and settlement purposes have substantially reduced the area covered by forests. Total Reserve Forest area has been reduced by 50 per cent during the last 20 years. There is a continuous loss of valuable mangrove forest in the Sundarban of Khulna and Chakoria.

Tree planting should be intensified and should be included in agro-forestry projects, along roadsides and embankments, newly accrued land and within homesteads. In the post-Rio period government of Bangladesh has emphasized tree planting as a major activity.

Fishery

Fish is the major supplier, cover 80 per cent of animal protein. More and more people, particularly the poor, rely on fishery as their main or supplementary incomes. This causes over-exploitation of the fishery resource and challenges the sustainability. Fishery is often the only livelihood open to the landless and unemployed.

Management and tenurial issues are the main reasons for the very low productivity of ponds and closed water bodies. Prospects are good for aqua culture and shrimp farming, but sometimes, the activity competes with agriculture and forestry, particularly, in the coastal areas.

Construction of indiscriminate flood control structures impede the flow water and consequently flood plain productivity. It is feared that some structures have reduced indigenous flood plain fisheries by over 70%.

Industry

Bangladesh has welcomed the establishment of industries which can contribute to economic growth and increase employment opportunities. A few of national and international companies have capitalized on the near total lack of enforced industrial and marine pollution regulations to exploit

natural resources such as fuels, minerals, timber, fish, shrimp and leather at the expense of the environment. Open water fishery has been a direct victim of industrial expansion through its untreated pollutants.

Environmental Awareness and Education

Environmental awareness cannot be addressed adequately through the formal education system. Awareness must also be created through non-formal means since the national overall literacy rate is around 35 per cent, with female literacy is estimated at only around 20 per cent.

People are, in general, articulate and perceptive. They have traditional knowledge and a *feel* for environmental issues, particularly, as they affect their daily life. But little formal information reaches the rural population. An environmental awareness drive is urgently needed and the government and the NGO's could share the burden. Some effort have been made, mostly by NGO's.

Linkages between Population, Development and Environment

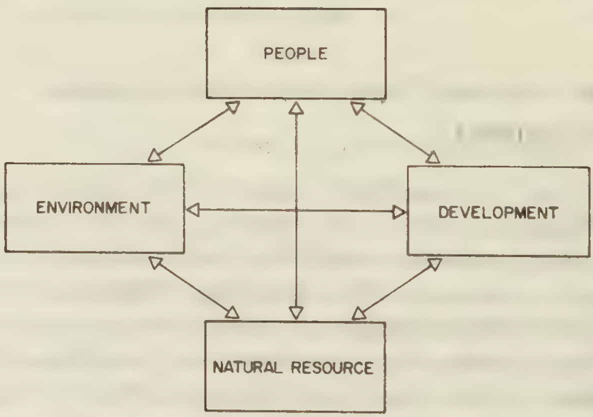
There are at least two major issues related to the population, environment and development nexus. In the first instance, one can reasonably ask if population pressures have not added to the stresses on natural resources and prompted their overuse and a subsequent decline in the productivity of those resources, just at a time when increased demand for development and higher levels of production has grown, thereby exacerbating the problem of overuse and depletion of a finite resource base. Secondly, are there not definite limits or at least natural resource related constraints to continued population growth and development ?

The environment-development linkages must be considered in the context of the people and available natural resources. These interactions are demonstrated in Figure 6.

In the first case, it is evident that the extremely high population density of Bangladesh has contributed to the intense use (and overuse) of forests, fisheries and to a certain extent even soil and water resources. A majority of households are already without sufficient areas of land to raise enough food to meet their needs. Fuel wood stocks have been depleted and diminished to

Figure 6

THE SCHEMATIC REPRESENTATION OF LINKAGES BETWEEN ENVIRONMENT AND DEVELOPMENT



the point where over 84 per cent of the total domestic energy requirements must be met by crop residues and dung with only 16 per cent being met by fuel wood. Particularly, when one considers the projected population levels of the year 2000 and beyond, it does appear that population density has clearly outstripped the potential for sustained yield production of fuel wood for domestic energy consumption from existing sources of supply.

Yet, forests, fisheries and other "renewable" resources are in much the same category as agriculture or food production: a condition of scarcity or shortages today does not necessarily imply that some absolute limit has been passed and that the carrying capacity of the environment has been exceeded. Carrying capacity can be a useful concept for assessing the potential for supporting wildlife populations which cannot fundamentally "develop" their environment, alter their systems of social organization so as to change the "rules" or policies governing the access and use of resources, and make use of new technologies to better meet their increasing needs from a finite resource base. People, communities and governments can do all of the above. For example, in Rwanda, there are now more trees on the landscape than 20 years ago and fuel wood scarcities have diminished, although population has been increasing at a rate of more than 3 per cent per annum and FAO statistics indicated a severe fuel wood "deficit" in 1980. Private tree-planting on farms has increased sharply, in response to supportive government policies and programs, open markets, secure tenure and a favourable environment for "tree culture".

Population and Natural Resource Management

In Bangladesh, the current population pressures clearly argue for very careful assessment of the use and management of natural resources primarily because so many people are already dependent on them. A proposed intervention which adversely affects the productivity of the remaining natural forest or fishery is more likely to impact the livelihood of someone in Bangladesh than in most other countries.

Similarly, the high density of population in Bangladesh requires a careful examination of the relationship between people and the land and a frequent reassessment of the potential for more productive and equitable use and sharing of natural resources. It would be incorrect, for example, to assume that population pressures have resulted in uniformly intensive land use;

although some areas are inherently less productive or more marginal in terms of agricultural production, it does appear that there is still considerable scope for the development of more diversified and productive farming systems. This has been discussed in the Bangladesh Environment and Natural Resource Assessment, 1990.

It would also be incorrect in a number of instances, to assume that overuse or depletion of a resource is simply a function of population pressure; for example, forest reserves in the vicinity of pulp and paper mills are being over harvested to produce wood which is being sold well below its market value.

In Bangladesh, it is particularly unfortunate that so many should remain landless, and even without a homestead, when relatively large areas of *khas* lands and other expanses of degraded or moderately productive land are not intensively managed and utilized by government agencies which have jurisdiction over them. Government control presumably need not preclude leasing arrangements and other mechanisms to mobilize interested local communities in rehabilitation and improved management of lands that conceivably could be made more productive. In fact, given the momentum of continued population growth, such intensification of land use and resource management on degraded lands and under-utilized areas is essential, if pressures to overuse and deplete other more intensively exploited areas are to be held in check.

Poverty and Environmental Stress

In addition to population pressure, many observers and analysts also point to the contribution of poverty to resource overuse and environmental degradation. Clearly, there is a relationship between poverty and environmental stresses; the poor are forced to address short term needs, even if their actions contribute to the long term depletion and degradation of the resource. And the poor are often the most vulnerable and least able to cope with environmental changes and the impacts of natural disasters and hazards. Poverty can also seen to be a factor in continued high rates of population growth—owing to the associated lack of health care services, security, educational and employment opportunities (Bangladesh Environment and Natural Resource Assessment, 1990). Further, the poor are driven to survive in the most hazardous ecosystems such as the coastal areas affected by

frequent cyclones, char-lands which are often flood prone and unstable and urban slums with a most meagre facility.

The links between poverty, environment and development also argue for careful analysis of alternative means to alleviate poverty and promote development while safeguarding and even increasing the extent and productivity of natural resources which can be used and managed by the poor as they develop more sustainable and productive livelihoods. For example, many NGO's have supported an income-generation project based on aquaculture development; 5 ponds covering 5 acres have been developed, to yield an annual catch of 20,000 pounds of fish, which will generate an income of some Taka 280,000 or $7,000 to defray the costs of a primary health care centre, extension activities and primary school. A project can also provides employment and the produce from fruit trees planted around the borders of the ponds. Many NGOs of Bangladesh, such as, Grameen Bank, Bangladesh Rural Advance committee (BRAC), Proshika have initiated innovative programmes of using people to manage their natural resources better.

Employment generation remain a key problem associated with poverty alleviation. The poorest do not have the purchasing capacity to buy their survival basic needs. Employment in the crop based agriculture show little possibility of expansion. Hence aquaculture, poultry, livestock, horticulture offer some potential for expansions and many NGOs are trying to use these opportunities. One of the key employment questions is to absorb the excess population in the rural areas with new opportunities thus halting or slowing of migration to urban slums. Environmental activities such as ecosystem regeneration offer some potential for this.

Some of the urban poor and slum dwellers who tend to eke out a living from servicing the urban sector or living on the wastes of the urban rich. But many of them have a life of dehumanizing chores and awful sanitary and social conditions, in many cases worse than the rural system they left. The urban life is most often devoid of any social support system or kinship network. The children from the urban areas collect any rubbish paper, plastic bags from dustbins and contribute to a developed recycling system. A recent estimate has shown that Dhaka city alone has over 200,000 potential street children with very little social or institutional support and the phenomena is growing (Helen Rahman, Situation Report on Street Children of Dhaka, 1992) Further, despite many efforts the number of children working as

domestic servant is also increasing rapidly indicating increasing poverty among the poorest families.

While it is beyond the scope of this assessment to attempt to define the upper limits for continued population growth which are related to natural resources, there are clearly both practical or near term (if not absolute) limits and costs associated with accommodating a growing population in a finite environment. Even the most carefully considered resource management plans cannot cope with ever-increasing populations; in this respect, it is vitally important to maintain a strong commitment to family planning and population stabilization and to increase the effectiveness of programs in this area (Bangladesh Environment and Natural Resource Assessment, 1990). But many mega processes are beyond any control of the poor. Examples are: sea level rise due to global warming, imposition of flood control structure resulting in drying of wet lands, increasing salinity due to restricted water supply or water withdrawal beyond the border of Bangladesh, drought in the north west, enhanced precipitation or snow melt causing floods and river bank erosion.

Sustainable Use of Resources

Sustainable development is the lasting use of resources. Short sighted use of resources to meet today's needs occurs in Bangladesh in the management of land, forest and fishery. Uncoordinated and uncontrolled projects harm the environment and hamper sustained development. With Bangladesh's limited resources, there is a need to stop the short-sighted unsustainable development which leads to forest removal, discharging toxic chemicals, removing coral and overexploiting fishery. There is a need for long-term multi sectoral planning based on the knowledge and wisdom of all involved in the development process. Emphasis is to be placed on projects and programs which promote economic development but yet conserve or enhance the productivity of ecosystems and the quality of the environment. Without sustainable development and use of resources now, future generations will face a very grim situation indeed.

Any attempt to achieve sustainable resource use must be based on a process which is politically acceptable to the people. One of the more effective approach would be to develop a better understanding of the six linkage represented in Figure 6. While environment is the base of the

existing and ever-dynamic natural resource, development is a process undertaken primarily by the people often affected by the machinery of government and non-government agencies. In a densely populated country, such as Bangladesh and a hard working population, it is mobilization of the people that offers the only hope for sustainable development. The energy, choices and the wisdom, both traditional and recently acquired, of the people, must be the basic strength of achieving sustainable development in a low resource-high population ecosystem.

For this purpose sectoral approach soon meets its limits and systems approach offer a far greater potential. An example of such interactive sub systems of land, water, and human activities for the coastal ecosystem is illustrated in Figures 7 and 8. An action, based firstly on peoples acceptance and secondly on the clarity of understanding of the interactions, as shown in Figure 6 and specially illustrated in Figure 8, as an example, offers an opportunity to overcome the limitation of sectoral and often myopic view of development. This systems approach, where if not all, most key interaction are understood and acted upon, offers an alternative to achieving sustainable development keeping people and their decisions at the centre stage. A specific effort must be made to use resources with a view to future generations capacity to access and use the same resource. This has to be an exercise in awareness and capacity building.

Dynamics and Non-equilibrium

It is evident in Bangladesh that current environment conditions are not in equilibrium. One example which indicates an imbalance is the food grain deficits which usually occur. Another might be the lowered ground water table in the northern and central parts of Bangladesh, prohibiting access to drinking water in those areas during certain periods of the year by normally established means. Some of the major problems which are undermining resource sustainability are:

- Low involvement of people in decition making, at local and central levels.
- Unrestricted access to resources (fishery and forests for example).
- Low capacity of local govt. to take an action and decision.
- Land ownership, for examples, in the coastal areas, by the wealthy elite.

Figure 7

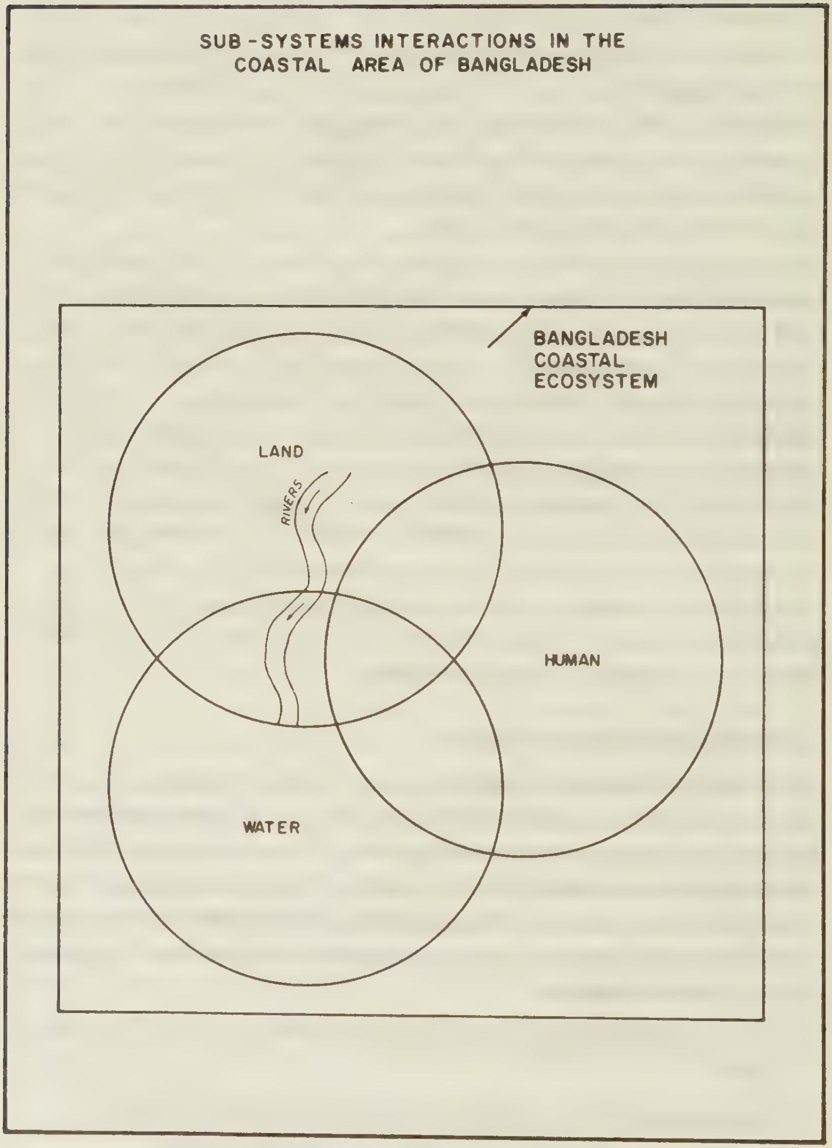
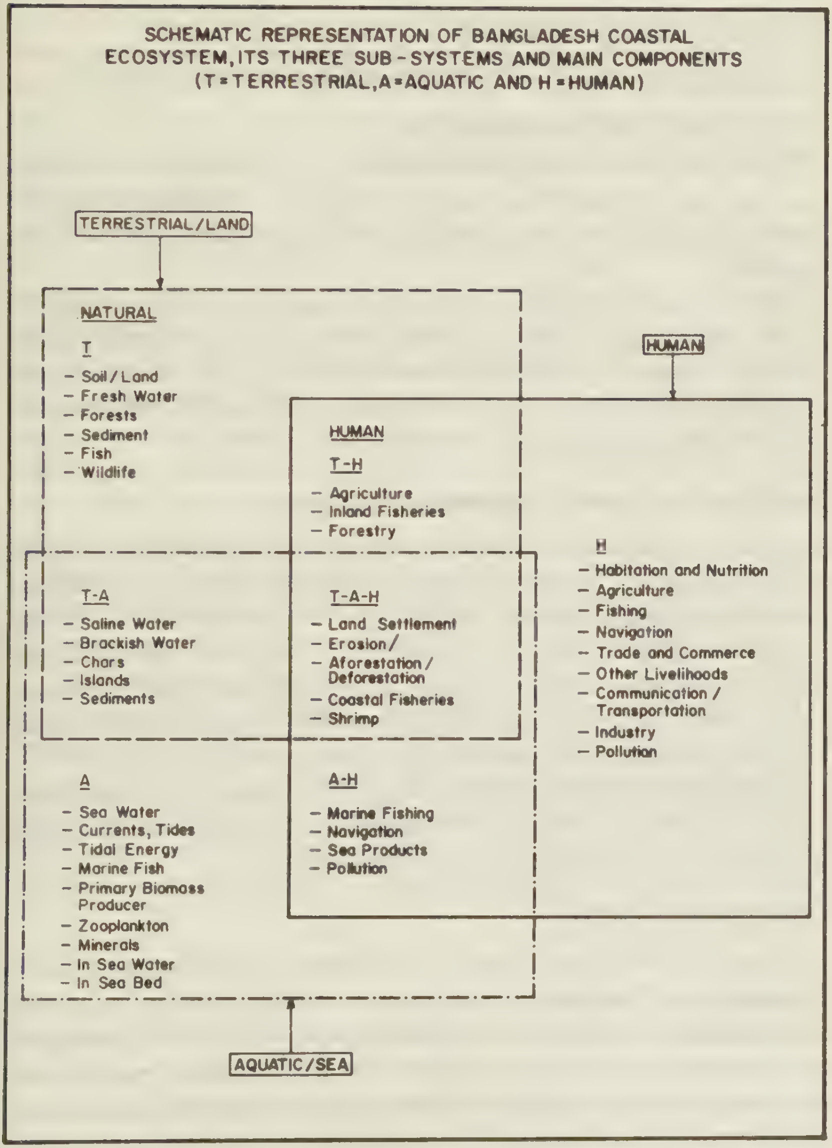

SUB-SYSTEMS INTERACTIONS IN THE
COASTAL AREA OF BANGLADESH
BANGLADESH
COASTAL
ECOSYSTEM
LAND
RIVERS
HUMAN
WATER

Figure 8


SCHEMATIC REPRESENTATION OF BANGLADESH COASTAL ECOSYSTEM, ITS THREE SUB-SYSTEMS AND MAIN COMPONENTS (T=TERRESTRIAL, A=AQUATIC AND H=HUMAN)
TERRESTRIAL/LAND
HUMAN
NATURAL
T
– Soil/Land
– Fresh Water
– Forests
– Sediment
– Fish
– Wildlife
HUMAN
T-H
– Agriculture
– Inland Fisheries
– Forestry
H
– Habitation and Nutrition
– Agriculture
– Fishing
– Navigation
– Trade and Commerce
– Other Livelihoods
– Communication / Transportation
– Industry
– Pollution
T-A
– Saline Water
– Brackish Water
– Chars
– Islands
– Sediments
T-A-H
– Land Settlement
– Erosion/
– Aforestation / Deforestation
– Coastal Fisheries
– Shrimp
A
– Sea Water
– Currents, Tides
– Tidal Energy
– Marine Fish
– Primary Biomass Producer
– Zooplankton
– Minerals
– In Sea Water
– In Sea Bed
A-H
– Marine Fishing
– Navigation
– Sea Products
– Pollution
AQUATIC/SEA

- Lack of public understanding of the problems.
- Rapidly expanding population.
- Inability to monitor sectoral changes and lack of trained personnel.
- Inability to take a systems approach.

In conjunction with the problems above, is the very limited resource base existing in Bangladesh making it even more imperative that the country and all of its development partners, seek a sustainable use of the resources.

With increasing population, landlessness and poverty, environment and sustainable resource management become key issues in development planning. If ownership and control of resources remain with the wealthy and influential, development from the bottom up and improved sustainable utilization of existing resources will continue to be difficult.

Need for Public and Community Awareness

Another major issue which cuts across all sectoral considerations is the absence of grassroots, community, public, or even in many cases, relevant agencies awareness of the what, why and how of sustainable resource utilization for a sustained quality of life, now and into the future. Public or community participation and understanding of the future with reduced resources due to current over-exploitation is vital now. Many of development program of several leading NGOs and their target groups (i.e. the landless poor to marginal farmers) have an understanding of the production patterns in existence around them and realize or have experienced environmental fluctuation in some resources they are intimately linked with.

Institutional Aspects

Presently, there is lack of strong institutional mechanisms within the Government of Bangladesh, having and exercising authority to promote sound environmental development. There appears to be a lack of understanding of the problems and a lack of political will to formulate regulatory and development policies in line with the needs for a sustained resources use program which is environmentally sound. Most of the individual in these agencies have been trained in traditional sectoral management with a short time planning horizon. They are often incapable to handling multi

dimensional and multi sectoral issues as would be required in sustainable development. Even one year after UNCED and signing the Rio Declaration and the Climate and Biodiversity conventions, very little has been done by Bangladesh government to take advantage of opportunities offered by new ever growing international instruments or initiatives in the negotiations of the two conventions. Bangladesh and its governmental machinery has been too engaged in its traditional mode of resource use, and attitude to its people and its communities.

The message of sustainable development, must take the centre stage of national politics and not be confined to environmentalists and a few non government organizations. The environment-development linkage will be best served with a better understanding of the people-natural resource linkage and integrating these to the former. To do so effectively institutions must develop their own capacity to react to the new thinking of sustainable development and re-orient themselves to be more responsive and pro-active. Capacity to address these linkages must be developed in the political process, the government agencies and non-government organizations, the private sectors, academic institutions, and community groups.

Despite all the shortcomings, the recent political process of democratization gives new hope and must take into account the four-cornered interactions between, natural resource—people—environment—development.

It must unleash institutions to be more effective and vigorous in pursuing the objectives of sustainable development, in alleviating poverty and at the same time protecting the resource base for a future generation. The decrease in the rate of population growth is expected to be a logical and reinforcing consequence. In mobilizing people and their capacity a functional and effective education plays a vital role and awareness about sustainable development can be adequately built in into that process of mass-mobilization.

CHAPTER TWO

AN ENVIRONMENTAL PROFILE OF BANGLADESH

Saleemul Huq and A. Atiq Rahman

Introduction

This chapter briefly describes the physical environmental setting of Bangladesh along with some of the major environmental features. The purpose is not to address any of the issues in depth as these are dealt with in the subsequent chapters but rather to provide an overview of the physical environmental setting of Bangladesh so that the specific topics dealt with in the subsequent chapters can be seen as part of the larger context. Thus each of the chapter authors has deliberately avoided giving a general background of Bangladesh which is to be provided by this chapter.

The setting

Bangladesh lies just north of the Tropic of Cancer between 20 and 26 degrees north latitudes and in the Eastern Hemisphere, between 88 and 92 degrees east longitudes (Figure 1). It lies at the confluence of three of the world's major rivers, namely the Ganges, the Brahmaputra and the Meghna which all originate from the Himalayan system and flow through China, Nepal and India before passing through Bangladesh as they drain out into the Bay of Bengal. Figure 2 shows the catchment area of these rivers which flow into the Bay of Bengal. The striking feature of this system is that Bangladesh's territory of only 144,000 square kilometres occupies an extremely small part of the system at its lower end. Thus, 93% of the waters passing through Bangladesh come from outside its boundaries while only 7% is from precipitation within its borders.

Figure 1

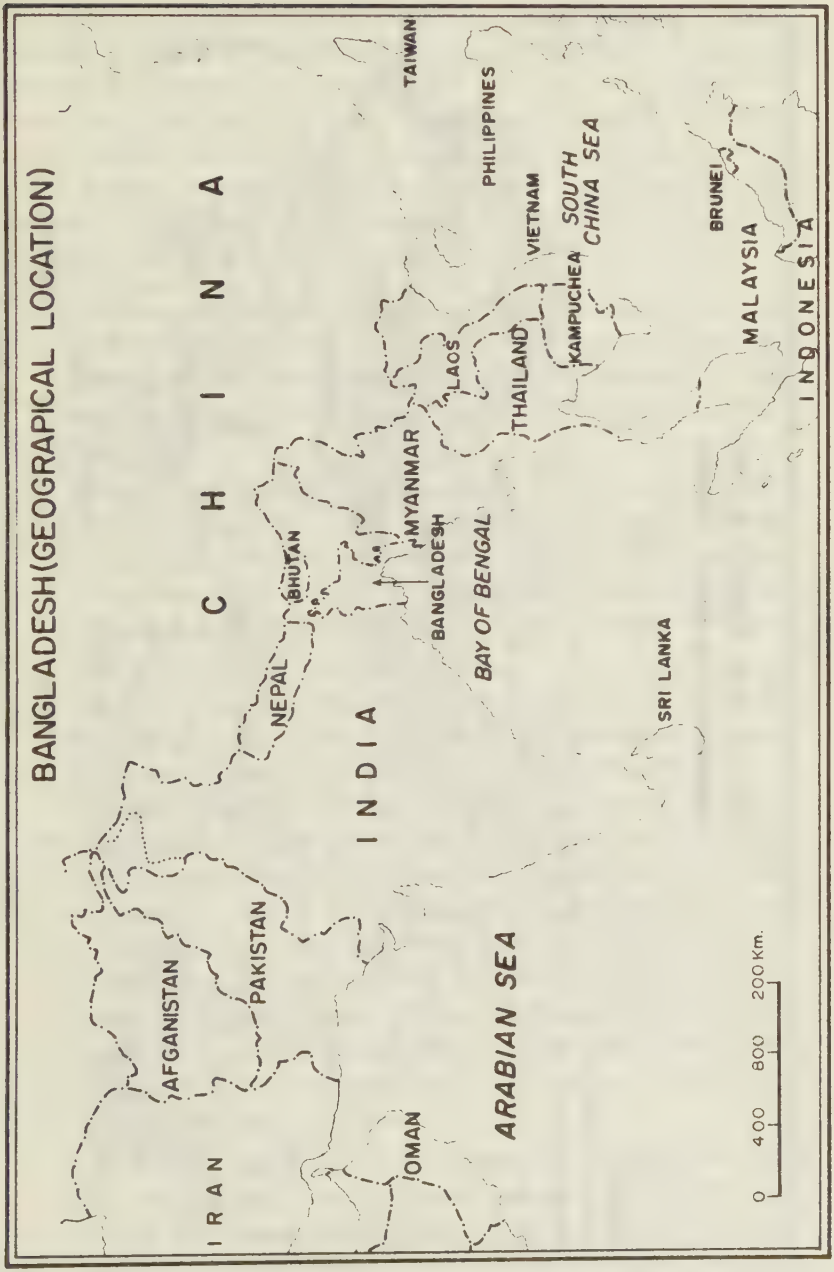

BANGLADESH (GEOGRAPICAL LOCATION)
CHINA
TAIWAN
PHILIPPINES
VIETNAM
SOUTH CHINA SEA
BRUNEI
MALAYSIA
INDONESIA
KAMPUCHEA
LAOS
THAILAND
MYANMAR
BHUTAN
BANGLADESH
BAY OF BENGAL
NEPAL
INDIA
SRI LANKA
PAKISTAN
AFGANISTAN
ARABIAN SEA
IRAN
OMAN
0
400
800
200 Km.

Figure 2


MAP OF THE GANGES & THE
BRAHMAPUTRA RIVER BASINS
0 50 100 200 Km
LEGEND
International Boundary
Watershed Boundary
Barrage
H I M A L A Y A N S
NEPAL
BHUTAN
BANGLADESH
UTTAR PRADESH
ASSAM
INDIA
BAY OF BENGAL
Lhasa
Tsela Dzong
Tangpo
Konggyu Tso Lake
Kathmandu
Darjeeling
Lakhmipur
Brahmaputra
Gauhati
Jamuna
Padma
Dhaka
Chittagong
Calcutta
Farakka
Ganges
Chapra
Ghagra
Allahabad
Son
Kanpur
Dehradun
Hardwar
Narora
New Delhi
Okhla
Chambal
Jaipur
Kotah
Betwa
28°
24°
76°
80°
84°
88°
92°
96°

Rivers

As a consequence of being at the lower end of the delta of these major river systems, Bangladesh is criss-crossed with over 200 rivers, which form a complex and ever-changing pattern as they pass through the country on a north to south trajectory (figure 3). They total approximately 24,000 kilometres in length and cover 7% of the country area. The average total annual flow of all the rivers and streams has been estimated at 38,000 cubic metres per second. The major river systems are:

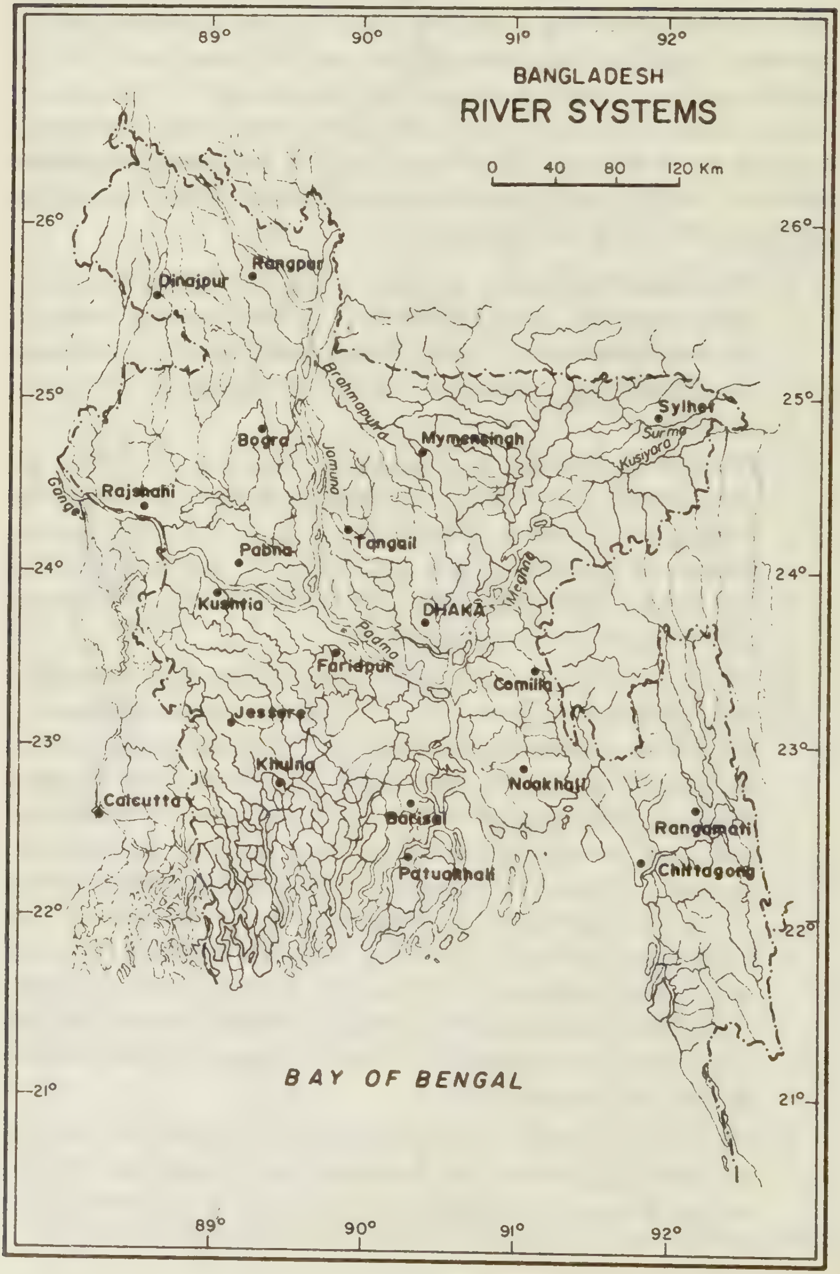
a. *The Ganges-Padma River System:* Starting from the southern slopes of the Himalayas, it travels 2400 km. of Indian territory and enters into Bangladesh near Rajshahi. While in India, the Ganges is charged by water from many tributaries including the Karnali, the Gandak and the Kosi.

   From the entrance into the Bangladesh territory, the river flows another 70 miles (112 km) before joining the Brahmaputra-Jamuna at Goalundo, 170 miles (270 km) north of the Bay of Bengal. In Bangladesh, the river receives one tributary, the Mahananda, joining it at the left bank in Rajshahi. The Ganges drains a total area of 430,000 sq. miles (1.1 million sq km).

b. *The Brahmaputra-Jamuna:* It reaches Bangladesh from the State of Assam, forming the border with India over a distance of 45 miles (72 km). Upon entering into Bangladesh, the Brahmaputra-Jamuna branches into two. The main course flows to the south through a wide and highly unstable channel, filled with islands and sand bars, built from its own movement, until it meets the Ganges-Padma at Goalundo. From here the confluents flow in a south-easterly course to join the Meghna at Chandpur. The minor channel, the Old Brahmaputra, had been the main course of the river only 200 years ago. It flows south-easterly to meet the Meghna at Bhairab Bazar. The Brahmaputra-Jamuna drains an area of 360,000 sq miles (930,000 sq km). Peak flows of up to 2,500,000 cusecs are reached between mid June and early September.

c. *The Meghna System:* The head-waters of the Meghna enter through two arms, the Surma and the Kushiyara, both of which have similar origins. The annual average discharge is around 125,000 cusecs,

Figure 3


BANGLADESH
RIVER SYSTEMS
0 40 80 120 Km
89° 90° 91° 92°
26° 25° 24° 23° 22° 21°
Rangpur
Dinajpur
Brahmaputra
Bogra
Jamuna
Mymensingh
Sylhet
Surma
Kusiyara
Ganges
Rajshahi
Tangail
Pabna
Meghna
Kushtia
DHAKA
Padma
Faridpur
Comilla
Jessore
Khulna
Calcutta
Noakhali
Barisal
Rangamati
Chittagong
Patuakhali
BAY OF BENGAL

about the same as that of the Nile Flood flow is in the order of 420,000 cusecs.

d. *The Chittagong region rivers:* These are relatively swifter rivers originating from the hills and mountain-streams of the Bangladesh-Burma border. They are subject to flash floods quite frequently. The system also includes the Kaptai lake which is the biggest lake in Bangladesh created by the hydro-electric dam at Kaptai. The major rivers are: (i) the Karnafuli which originates in the Arakan Youmas in Burma and flows through India and the Chittagong Hill Tracts to Chittagong. Its estimated annual flow is 25 million acre-feet, (ii) the Sangu which originates in the Sangu Reserve Forest and flows into the sea about 16 kilometres from the mouth of the Karnaphuli, and (iii) the Matamuhuri which is also known as the Marma.

In addition to the rivers systems, there are also many beels (depressions), baors (ox-bow lakes) in the south-west and haors (seasonal floodplains) in the north-east.

Physiography

The main physiographic regions of the country are shown in Figure 4 with the detailed sub-regions in Figure 5. These are:

I. Himalayan Piedmont Plains

II. Tista Floodplain

III. Barind Tract:

  a. North-eastern outliers

  b. Eastern Barind

  c. East-central Barind

  d. West-central Barind

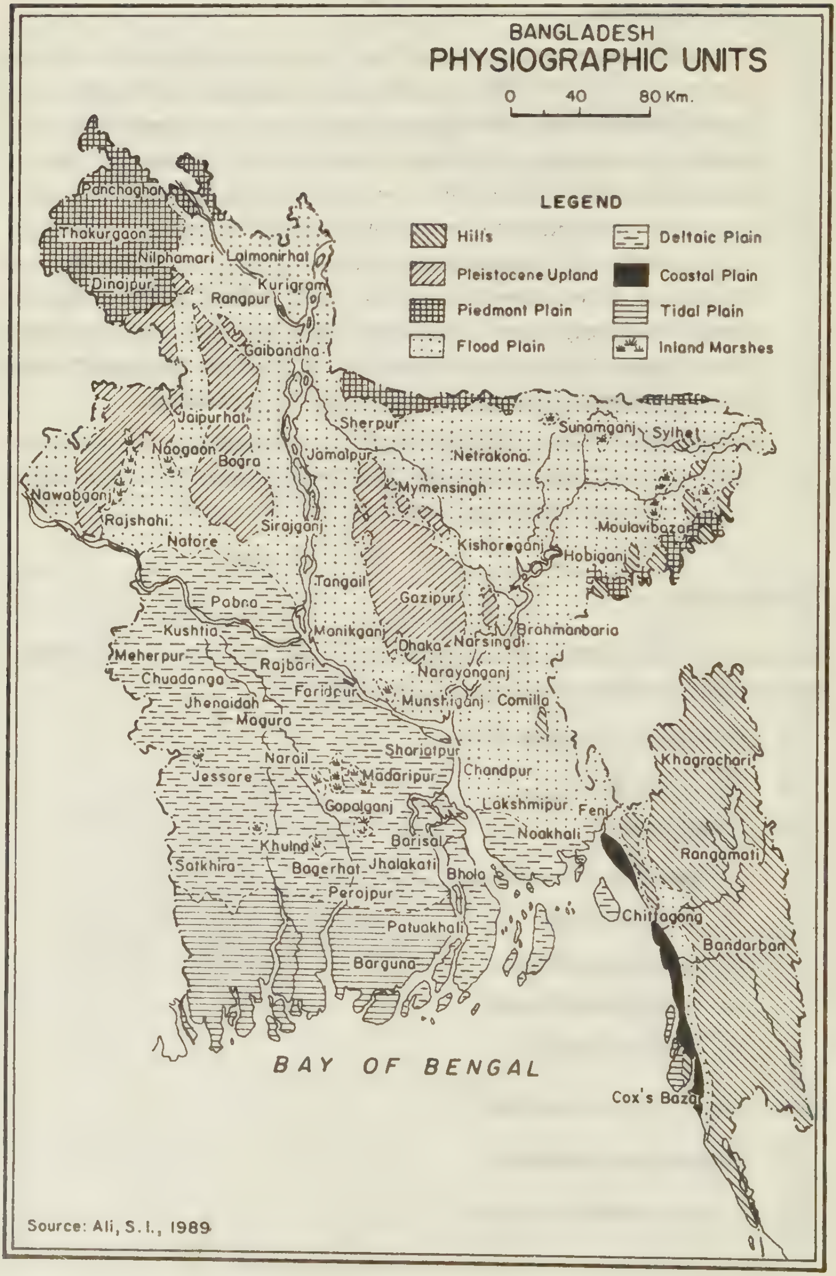
  e. Western Barind.

IV. Little Jamuna floodplain.

V. Middle Atrai floodplain

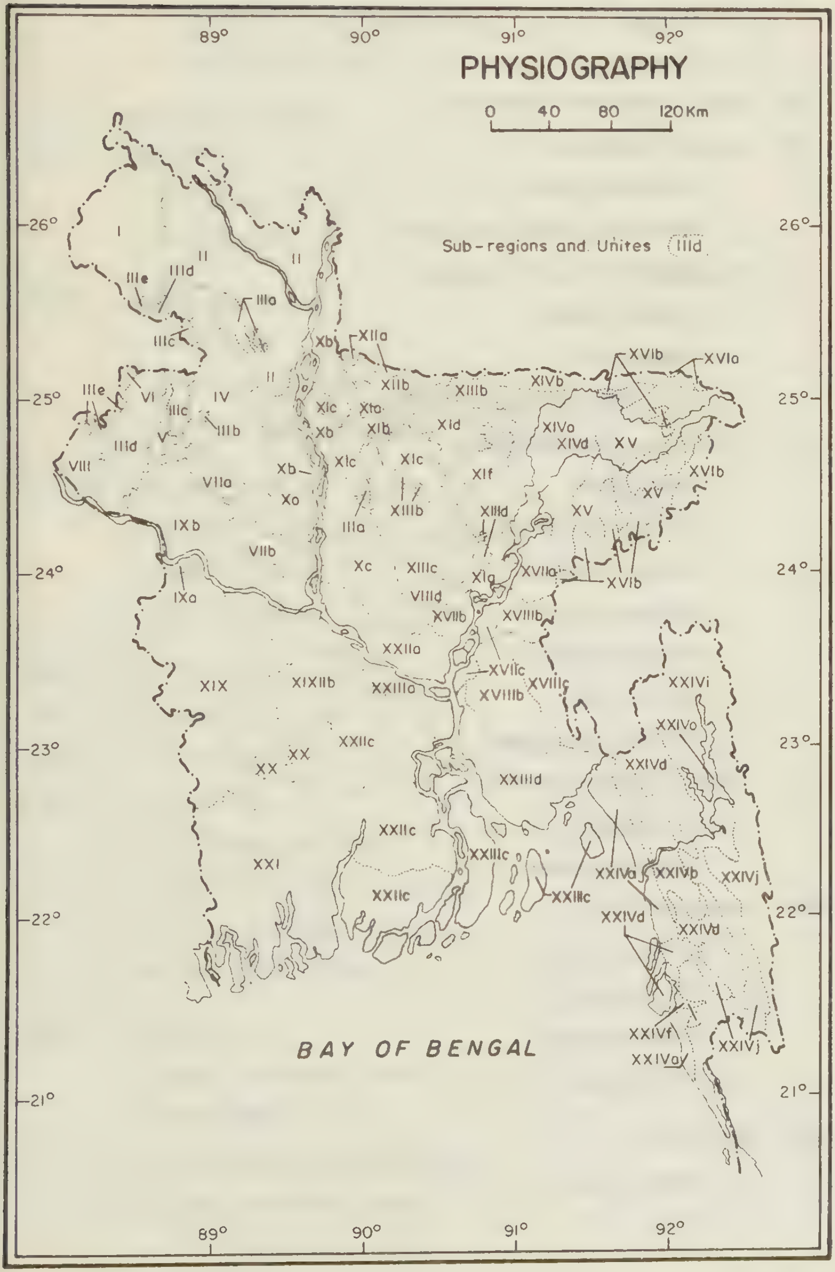
VI. Lower Punarbhaba valley

Figure 4



Source: Ali, S.I., 1989

Figure 5


PHYSIOGRAPHY
0 40 80 120 Km
Sub-regions and. Unites IIId
89° 90° 91° 92°
26° 25° 24° 23° 22° 21°
I
II
IIIa
IIIb
IIIc
IIId
IIIe
IV
V
VI
VIII
VIIa
VIIb
IXa
IXb
Xa
Xb
Xc
XIa
XIb
XIc
XId
XIf
XIg
XIIa
XIIb
XIIIb
XIIIc
XIIId
XIVa
XIVb
XIVd
XV
XVIa
XVIb
XVIIa
XVIIb
XVIIc
XVIIIb
XVIIIc
XIX
XIXIIb
XX
XXI
XXIIa
XXIIc
XXIIIa
XXIIIc
XXIIId
XXIVa
XXIVb
XXIVd
XXIVf
XXIVi
XXIVj
BAY OF BENGAL

VII. Lower Atrai Basin:

a. Western

b. Eastern

VIII. Lower Mahananda floodplain.

IX. Ganges floodplain:

a. Diaras and chars

b. North Ganges Old floodplain.

X. Brahmaputra-Jamuna floodplain:

a. Bangali-Karatoa

b. Diaras and chars.

c. Jamuna-Kaliganga floodplain.

XI. Old Brahmaputra floodplain:

a. High ridges

b. Floodplain complex

c. Western plain

d. Northern plain

e. Southern plain

f. Eastern plain

g. South eastern plain

XII. Susang Hills and Piedmont:

a. Susang Hills

b. Piedmont plains

XIII. Madhupur Tract:

a. Northern tract

b. Central tract

c. Southern tract

d. Eastern tract

XIV. Haor Basin:

a. Central basin

b. Susang Piedmont basins

c. Meghalaya Piedmont depression

d. Central Sylhet lowland

XV. Sylhet High plains

XVI. Sylhet Hills:

a. Meghalaya foot-hills

b. Tila ranges

XVII. Meghna floodplain:

a. Titas basin

b. Meghna-Laktia duab

c. Middle Meghna floodplain

XVIII. Tipperah Surface:

a. Eastern Piedmont strip and Lalmai range

b. Low floodplain

c. High floodplain

XIX. Moribund Delta

XX. Central Delta Basins

XXI. Immature Delta

XXII. Mature Delta:

a. Old Ganges floodplain

b. Padma-Madhumati floodplain

c. Non-saline tidal floodplain

d. Saline tidal floodplain

XXIII. Active Delta:

a. Active Padma floodplain

b. Mehendiganj islands

c. Meghna estuary islands and chars

d. Meghna estuarine floodplain

XXIV. Chittagong sub-region:

a. Northern Coastal plains
b. Central valley
c. Matamuhuri delta and coastal islands
d. Western hills
e. Middle Karnafuli system valleys
f. Bakkhali river valley
g. Southern beach plain
h. Nhila-Teknaf plains
i. Jinjira islets and reefs
j. Mountain ranges and eastern hills.

The land is also classified by the height as shown in Figure 5-6.

The main characteristic is that almost all the country is very low lying except for the hilly areas and is prone to periodic flooding from the different rivers.

Soils

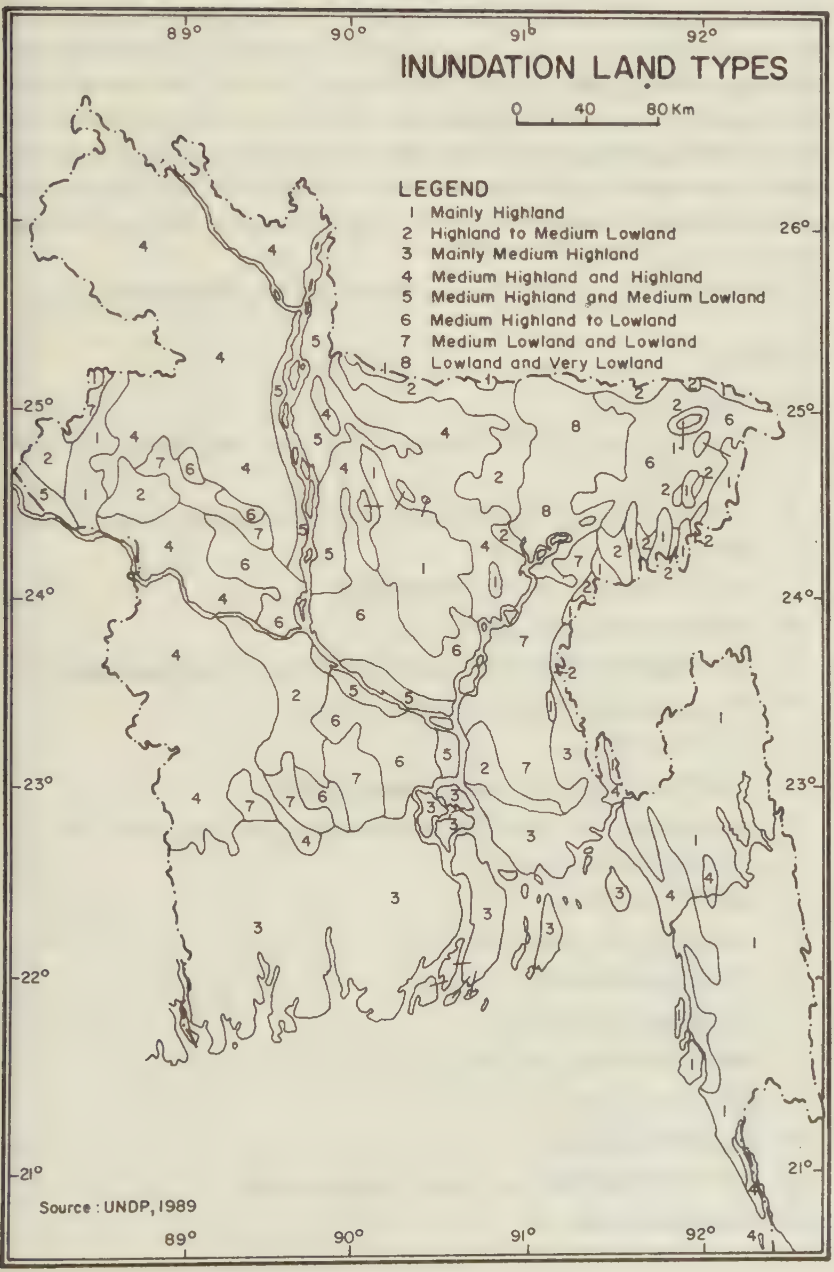
The soils of Bangladesh can be divided into seven distinctive tracts which can be grouped under three broad physiographic divisions as follows: (1) Hill Soils, (2) Old Alluvial Soils and (3) Recent Alluvial Soils.

The Hill Soils consist of hilly regions of Sylhet, Garo Hills in Netrakona districts and Lalmai Hills of Comilla district. They are composed of tertiary rocks and unconsolidated tertiary and Pleistocene sediments. The soil is distinctively acidic with pH variations from 5.2 to 5.6.

The Old Alluvial Soils include the tracts of Modhupur and Barind areas which have been formed on the alluvium of the Pleistocene period. They stand on the high land above the flood level and belong to the Latosol group of generic soils. They are clayey in texture, reddish to yellowish in colour, contain numerous ferrous concretions, are relatively rich in iron and aluminium, are highly aggregated and have a high phosphate fixing capacity. The soil is acidic with pH ranging from 5.2 to 5.6.

The Recent Alluvial Soils are found in the Gangetic alluvium, Teesta silt, Brahmaputra alluvium and in the coastal saline tracts. Gangetic alluvium is rich in calcium, magnesium and potassium. They also contain free calcium carbonate. Their soils are characterized by nitrogen and phosphate

Figure 6


INUNDATION LAND TYPES
0 40 80 Km
LEGEND
1 Mainly Highland
2 Highland to Medium Lowland
3 Mainly Medium Highland
4 Medium Highland and Highland
5 Medium Highland and Medium Lowland
6 Medium Highland to Lowland
7 Medium Lowland and Lowland
8 Lowland and Very Lowland
89°
90°
91°
92°
26°
25°
24°
23°
22°
21°
Source : UNDP, 1989

deficiency and locally by a strong alkalinity. The pH range is 7.0 to 8.5. Teesta silt tract soils are sandy to sandy loam in texture, without any profile development. They are flooded every year and as a result, are replenished by fresh deposit every year. The pH varies from 5.5 to 6.8. The coastal saline tract is part of the active flood plain, but is subject to flooding by saline water at high tide. A large part of the tract is occupied by mangrove forest, where some soils contain large amounts of sulphide in their profile. The soil is saline and in general, neutral but tends to be on the alkaline side. The pH varies from 6.9 to 7.5.

The major soil types are shown in Figure 7 and include the following:

Soil Tracts

1. Black Terai Soils
2. Non-calcareous Brown Floodplain Soils (dominant) and Grey Floodplain Soils
3. Grey Floodplain Soils (dominant) and Non-calcareous Brown Floodplain Soil
4. Grey Floodplain Soil, Nonsaline phase
5. Grey Floodplain Soil, Saline phase
6. Grey Floodplain Soil and Non-calcareous Dark Grey Floodplain Soils
7. Non-calcareous Dark Grey Floodplain Soils
8. Acid Basin Clays
9. Grey Floodplain Soils and Acid Basin Clays
10. Calcareous Dark Grey Floodplain Soils and Calcareous Brown Floodplain Soils 11. Peat
12. Acid Sulphate Soils
13. Non-calcareous Alluvium
14. Calcareous Alluvium
15. Red-brown Terrace Soils
16. Grey Terrace Soils and Deep Red-Brown Terrace Soils
17. Grey Terrace Soils
18. Grey Piedmont Soils
19. Grey Piedmont Soils and Grey Floodplain Soils
20. Brown Hill Soils

Figure 7

Climate

Bangladesh has a humid, warm, tropical climate which is fairly uniform throughout the country. There are three main seasons: (1) a hot summer season with high humidity from march to June, (2) a hot and humid monsoon season with heavy rainfall from June to October and (3) a relatively cooler and drier winter season from November to March. Maximum temperatures range between 20-40°C and minimum temperatures just above O°C. The higher temperatures tend to occur in the north and west but the geographical differences are not very great.

Rainfall ranges from 55" (1400 mm) to 140" (3500 mm) on average annually and is a critical risk factor in agricultural production. There are three main periods of rainfall: (1) the western depression of winter, (2) the early thunder-storms known as Nor'westers (North-westerlies) and (3) the summer rains from the southwest trades known as the monsoons. The main period of rainfall due to the western depression of winter is from 20 January to 25 February. During this period, it rains from 0.50" at Cox's Bazar to 1.50" or more at Srimongol. There is a short break before the second rainy period beginning on about 10 March but can vary from year to year.

The Nor'westers are due to a variety of reasons of which the main ones are the steady flow of cool, dry air above 6,000 feet from the northwest (anti-trades) and the warm, moist current up to 6,000 feet from the south, intense evapotranspiration in the Bengal Basin and Assam and Katabatic winds from the surrounding mountains. The main period of the Nor'westers lasts up to about 5 May. The rainfall varies in this period from 3" (Dinajpur) to 16" (Srimongol).

The main rainy period in Bangladesh begins with the coming of the moisture-laden southwest trades which are drawn to the Indian sub-continent by the intense heat and consequent low pressure over the Punjab and the Upper Ganges Valley and the filling up of the equatorial lows by air masses from these hot areas. These monsoons bring very heavy rainfall for about five months from the end of May to about mid-October. The total rainfall in these months varies from about 50" at Rajshahi to 130" at Cox's Bazar and over 200" in the northern parts.

The timing of the beginning of the monsoon rains and the extent and duration of the rains are critical factors in agricultural production,

particularly with respect to the grain or rice production. A delay of seven to ten days in the arrival of the monsoons can have dramatic impact on the total grain harvest. Excess rainfall in some years lasting for longer than usual can cause floods and consequent damage to lives, property, livestock and crops.

The Temperature and rainfall regimes of different parts of the country are shown in Figure 8 and the main climate types in Figure 9.

Agriculture

Water and agriculture are intimately connected. The rainfall, soils, temperature and water availability of Bangladesh make it ideal for agricultural production which has been practised for thousands of years and supported major civilizations. Even today, agriculture is still the mainstay of the country's economy providing about 50% of the Gross Domestic Product (GDP). Within the agricultural sector, crops account for about three quarters of total agricultural production and about 40% of GDP.

Land Use in Bangladesh is primarily for agriculture. About 35 million acres are cultivated, of which 60% is in crop production. Homesteads, cities and inhabited lands occupy about 20% while forests are officially considered to come up to 15% although the latter figure is generally accepted to be a gross overestimate due to major deforestation taking place. Bangladesh has some of the world's best tropical forest vegetation with mangrove forests in the Sundarbans on the coast and other forests in the hilly regions of Chittagong, Sylhet and Mymensingh. The forests are important sources of economically useful timber such as teak. They are also repositories of many exotic and rare species of plants and animals. Fuelwood, along with animal dung and crop residues provide about 70% of the energy requirements in the rural sector.

Cropping Patterns in Bangladesh are multifarious and varied according to the crops being grown, the agro-ecological region, the soils and other factors. The cropping patterns are in accordance with the rainfall pattern. The major crops of Aman rice and jute are grown during the monsoon rains. Other crops such as Boro rice, potatoes, oilseeds, pulses and vegetables are mostly grown in the winter months usually without irrigation while if irrigation is available, then high yielding rice or wheat will be grown.

Figure 8

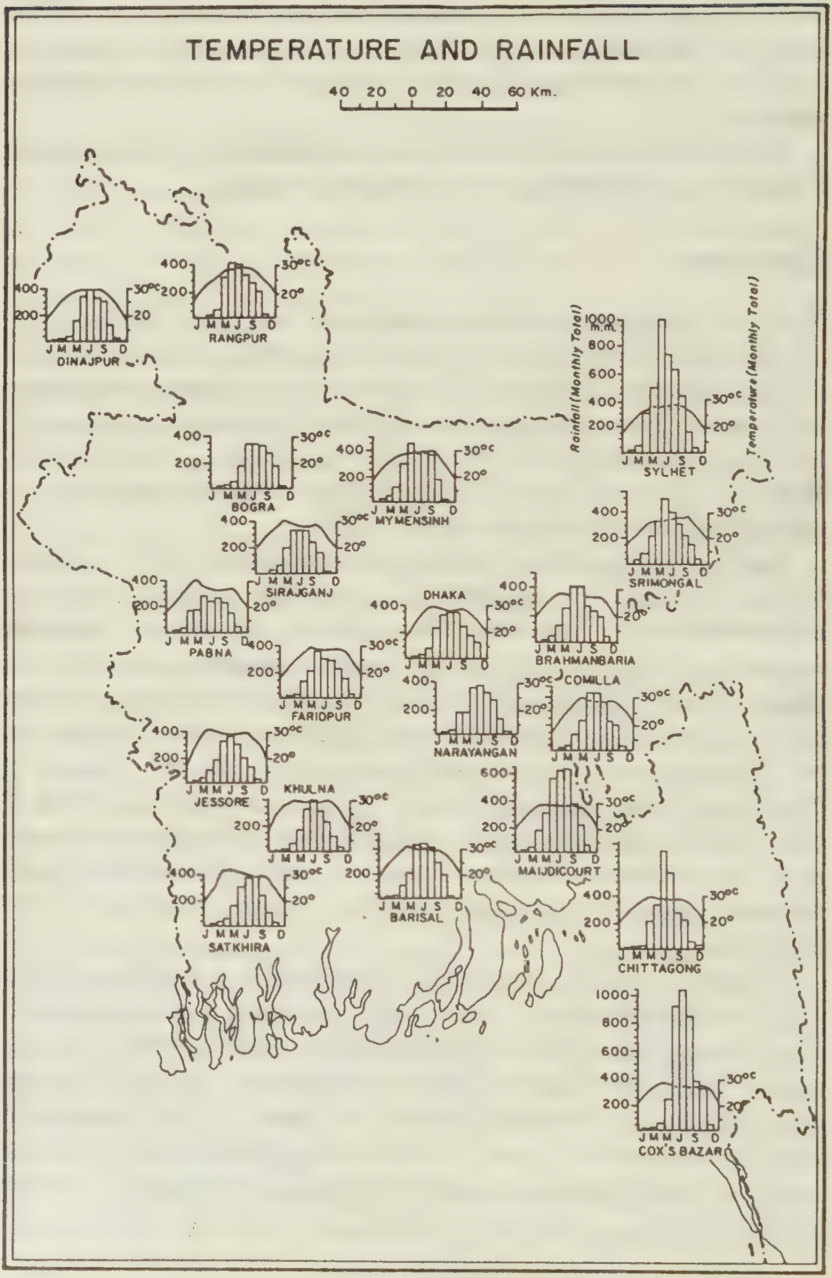
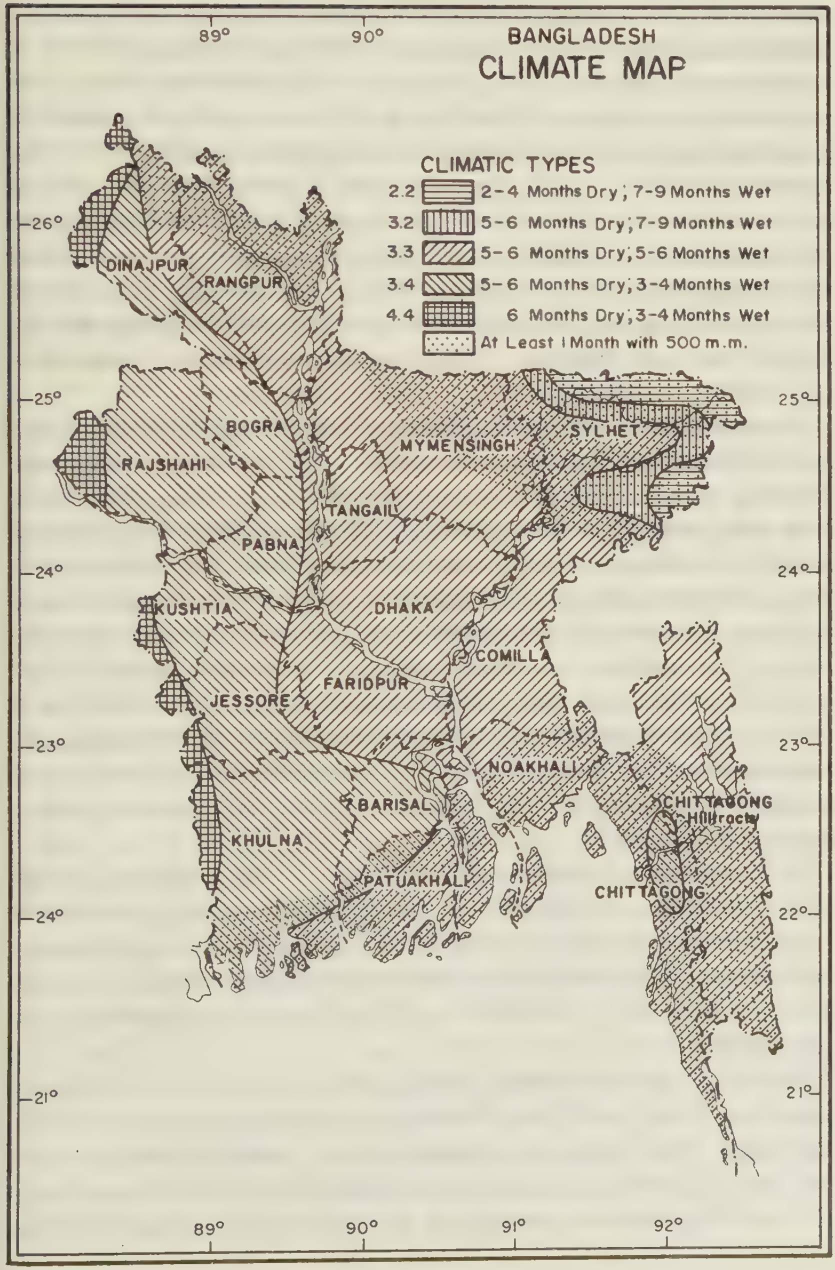

TEMPERATURE AND RAINFALL
40 20 0 20 40 60 Km.
DINAJPUR
RANGPUR
BOGRA
MYMENSINH
SYLHET
Rainfall (Monthly Total)
Temperature (Monthly Total)
SRIMONGAL
SIRAJGANJ
PABNA
DHAKA
BRAHMANBARIA
COMILLA
FARIDPUR
NARAYANGAN
JESSORE
KHULNA
MAIJDICOURT
BARISAL
SATKHIRA
CHITTAGONG
COX'S BAZAR

Figure 9


BANGLADESH
CLIMATE MAP
CLIMATIC TYPES
2.2 2-4 Months Dry; 7-9 Months Wet
3.2 5-6 Months Dry; 7-9 Months Wet
3.3 5-6 Months Dry; 5-6 Months Wet
3.4 5-6 Months Dry; 3-4 Months Wet
4.4 6 Months Dry; 3-4 Months Wet
At Least 1 Month with 500 m.m.
89°
90°
91°
92°
26°
25°
24°
23°
22°
21°
DINAJPUR
RANGPUR
BOGRA
RAJSHAHI
MYMENSINGH
SYLHET
TANGAIL
PABNA
KUSHTIA
DHAKA
COMILLA
FARIDPUR
JESSORE
NOAKHALI
BARISAL
KHULNA
PATUAKHALI
CHITTAGONG
Hilltracts
CHITTAGONG

Land Tenure and ownership are very important considerations in Bangladesh. The pressure of a rapidly expanding population has led to considerable land fragmentation over the past centuries and average farm size is now between 2 and 5 acres. A large proportion (about 50%) of the rural population own no land at all or only the land on which their homestead is located and are classified as landless. A large proportion (about 65%) of the agricultural land is cultivated by owner, small farmers while about 30% is cultivated on a tenancy or sharecropping basis. The structure of land tenure and land holdings in Bangladesh is a very important factor in agricultural production, particularly in the adoption of new technologies as the size of the farm holding, the status and financial situation of the farmer will all have an important bearing on his perception and attitude towards new technology.

Livestock and poultry are economically important agricultural resources in rural Bangladesh. Cattle provide the main power source for ploughing, threshing, transport and other rural energy requirements. They also provide milk and cow dung which is used as both fertilizer and fuel. However, the animals are genetically and physically poor and are low milk producers. They suffer deficiency in diets, particularly during the monsoon months and are generally infested with parasites. Veterinary care is particularly non-existent. Calving rates are very poor and mortality of calves in the first year is very high. The only commercial-scale breeding and use of livestock are at three governmental stations and the Agricultural University at Mymensingh. Artificial insemination is carried out by the government and improved breeds have been introduced but these have had little or no impact on the livestock situation in the country.

Poultry is an important source of protein both from the eggs and the birds. They are usually kept by each household, particularly by the women and children and are used for domestic consumption or as a supplementary income source. In recent years, both government and private sectors have gone into commercial production of poultry but these are only to supply the urban market.

Nutrition and diet of the majority of the population is an extremely important fact of development. Although adequate data is not available, the results of two studies undertaken by the Institute of Nutrition and Food Science of Dhaka University in 1962-64 and 1975-76 respectively showed a deteriorating nutritional status for large segments of the

population. Total food intake per capita decreased by 4% between the two studies.

Calorie intake declined by 7% to about 2000 per day which is only 93% of the Minimum Daily Requirement while consumption of vitamins A and C was drastically reduced. The nutritional deficiencies both in terms of calorific intake and balanced diet are particularly acute amongst the poorer families and most acute for their children. Only about 40% of the families consumed the minimum daily calorific requirement with about 90% of the families being deficient in essential vitamins. Amongst other findings of the study are the fact that 16% of children aged up to five years suffer acute and chronic malnutrition while 70% suffer from anaemia and vitamin deficiency.

The role of women in agriculture is of prime importance although its character reflects the traditions and culture of society in Bangladesh. Being predominantly a Muslim society in which women are meant to observe "Purdah" (be veiled), the role of women in the rural sector is mainly in household activities like cooking, drawing water, looking after poultry and also in homestead gardening and post-harvest processing of crops. In recent years, the pressure to allow women a greater role in economic activities had led to greater freedom for women, particularly in the urban sector where it is now common for women to work in the employment market.

Crop Production in Bangladesh in recent years has undergone some changes in terms of yields as well as crop distribution. Rice is by far the most important crop with jute, wheat, potatoes, oilseeds, sugarcane, pulses and tea amongst other important crops. Wheat production has increased in importance in the recent years. It has jumped to being the second most important crop in 1981 from the eight in 1973. Production in most important crops has increased in recent years with the exception of jute. Increase in overall production has been achieved mainly from improvements in crop yields of wheat and rice due to the adoption of high yielding varieties of these crops along with irrigation and fertilizer use.

Fertilizer use has increased dramatically in recent years, particularly with the spread of high yielding varieties of rice and wheat. Bangladesh produces urea and Triple Super Phosphate in the country but the needs outstrip supply by a considerable factor and fertilizer is imported up to 50% of the total amount used. New fertilizer plants under construction, however, will help make the country self sufficient in commercial fertilizer.

Irrigation has been a major factor in increasing crop production in Bangladesh. Total acreage under modern irrigation has risen by almost 7% annually since 1973 while acreage under traditional irrigation has shown a downward trend (0.5%). Modern irrigation methods include low lift pumps, shallow and deep tubewells. Most of the irrigated land is used for cereals (90%), particularly high yielding varieties of rice and wheat.

The total land under irrigation in 1982 was 4.3 million acres which represents only 13% of the 32 million acres of multicropped land in production, so the potential for further irrigation is enormous.

Agricultural Energy is provided mainly from human and animal sources. Some diesel and electrical power is used for irrigation. Home cooking and lighting are taken care of by agricultural wastes, cow dung, firewood or kerosene.

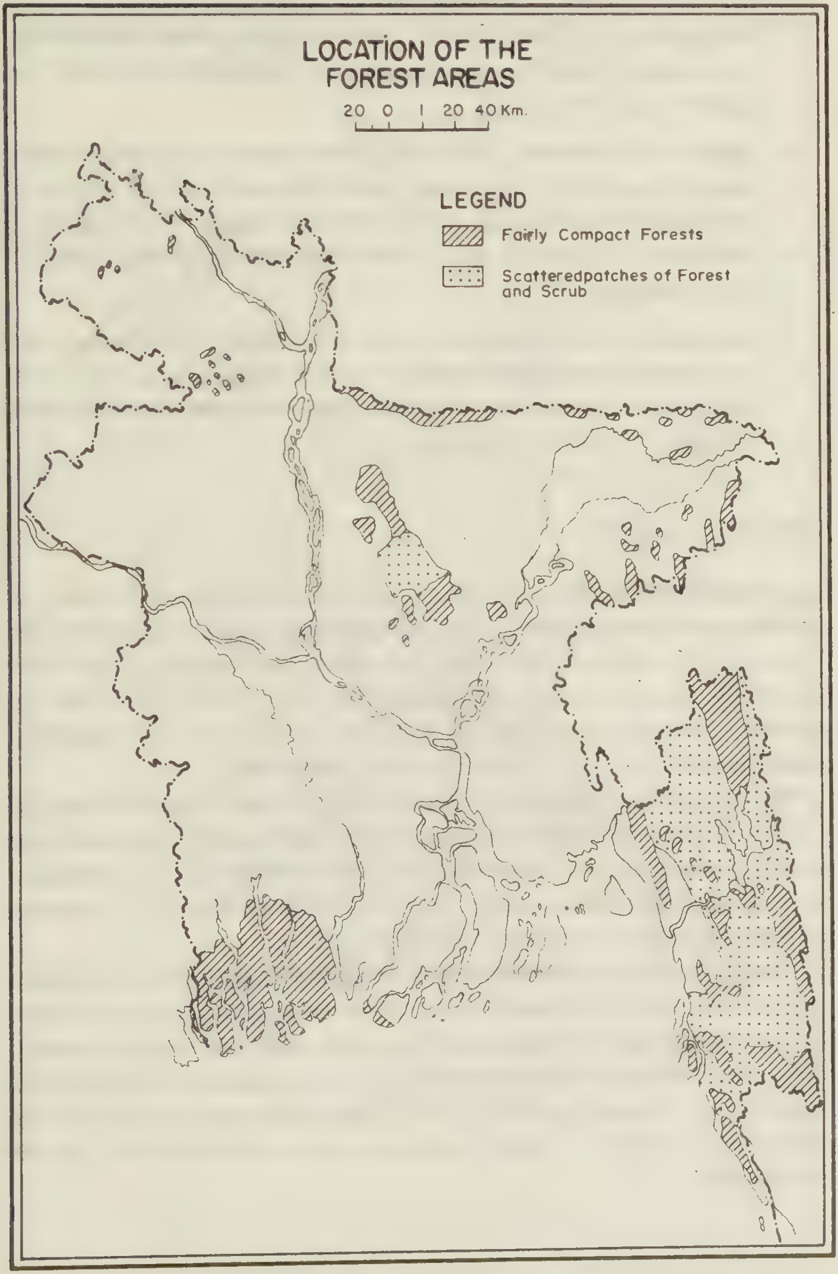
In some villages, electrical lighting is now available. Ploughing and other farm activities are done by animal power where the situation is becoming more and more precarious. Almost 40% of the farmers own no draught animals at all while another 10% own only one. Only about 50% of the farmers own adequate draught power. Ownership of draught animals is, of course, the lowest amongst the poorer farmers with the smallest land holdings.

Forests

Once very rich in tropical forests, Bangladesh is now losing its forest resources at a very rapid rate. The main forest areas are shown in Figure 10 and described briefly below:

1. *The Sundarbans:* Approximately 3,500 sq km of mangrove forests located in the south-western part of the country, together with the part in the neighbouring state of West Bengal in India, this is the largest mangrove forest in the world and home to a vast number of plant and animal species many of which are facing extinction. The most well known animal is the Royal Bengal Tiger which is a protected species and the most well-known plant is the tall Sundari tree which gives the forest its name and which is under threat from a disease known as "top dying" possibly due to increase in salinity because of reduced low season flows in the rivers.

Figure 10


LOCATION OF THE
FOREST AREAS
20 0 1 20 40 Km.
LEGEND
Fairly Compact Forests
Scatteredpatches of Forest
and Scrub

2. *Chittagong Hill Tracts:* These are the main Tropical Rain Forest in the south-eastern part of the country in the hills rising up to the Burmese border. There are thick vegetation and will animals including elephants. However, the forest is being rapidly depleted by indiscriminate tree-felling.

3. *Chokoria Sundarbans:* These mangrove forests in the south- eastern coast just south of Chittagong used to be an important mangrove forest but is has been destroyed almost beyond restoration by a combination of the felling for timber and clearing of forest land for shrimp farming.

4. *Deciduous forests:* These are in the relatively high Modhupur tract just north of Dhaka and consist of deciduous plants and a few wild animals such as monkeys. They are being very rapidly depleted both for timber as well as cultivation.

Natural Hazards

Bangladesh is one of those countries which are most prone to a variety of natural hazards ranging from floods to cyclones and droughts. One of the reasons for its vulnerability is the very dense population of over 1000 persons per sq. km. (Figure 11). Practically, every part of the country is vulnerable to some sort of hazard. Figure 12 shows the areas affected by natural hazards over only a 3 year period of 1988 to 1991.

The most devastating hazard from the point of view of loss of lives are cyclonic storms accompanied by tidal waves. Bangladesh receives several such storms annually and sometimes they can be devastating. For example, the cyclone of April 1991 claimed over 100,000 lives. Figure 13 shows the paths of major cyclonic storms over a 30 year period.

Besides the natural calamities mentioned above, Bangladesh is also prone to occasional earthquakes due to its location near a major tectonic fault line (figure 14). Although the earthquakes tend to be mild, they can occasionally be very severe such as one that had occurred in the eighteenth century which caused the Brahmaputra river to shift its course about 50 km. from its old course east of Mymensingh to its new course west of the town of Mymensingh.

Figure 11

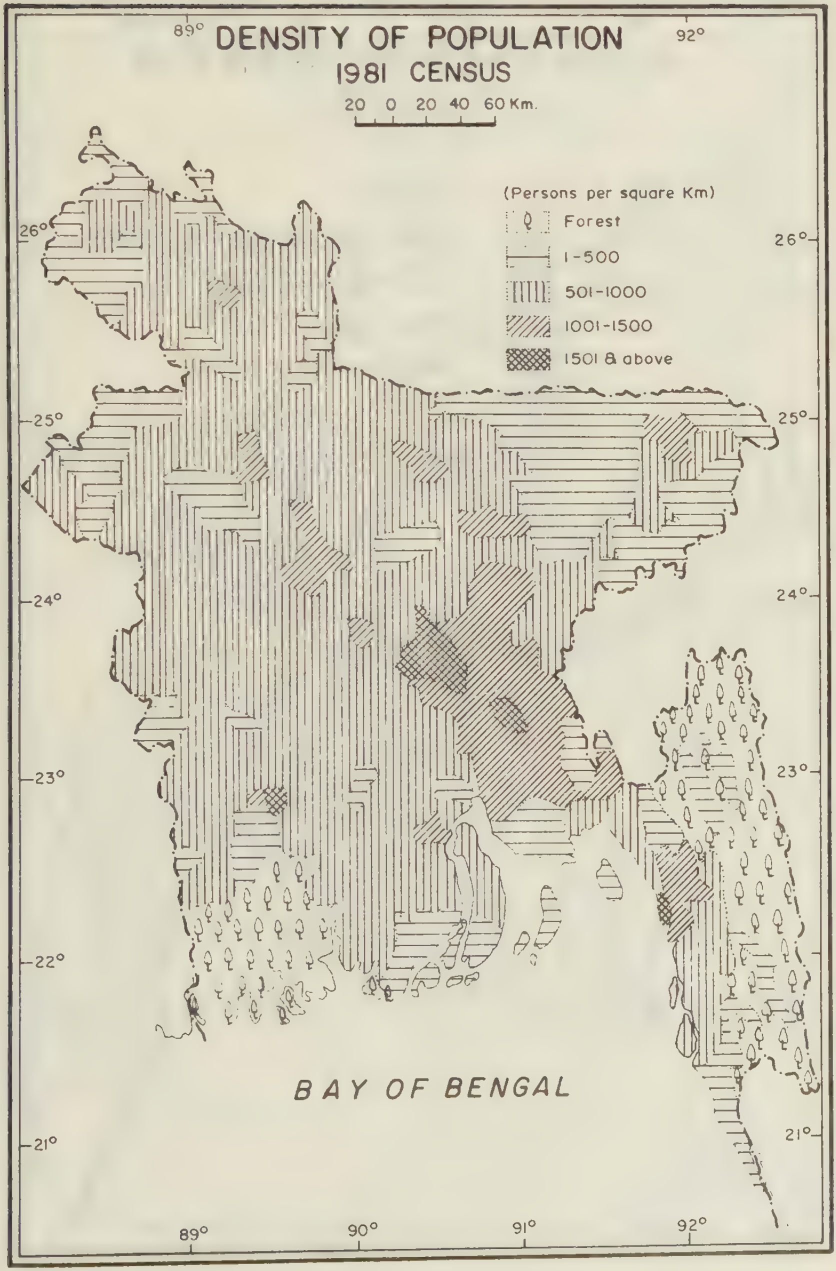

DENSITY OF POPULATION
1981 CENSUS
20 0 20 40 60 Km.
(Persons per square Km)
Forest
1-500
501-1000
1001-1500
1501 & above
BAY OF BENGAL
89°
90°
91°
92°
26°
25°
24°
23°
22°
21°

Figure 12

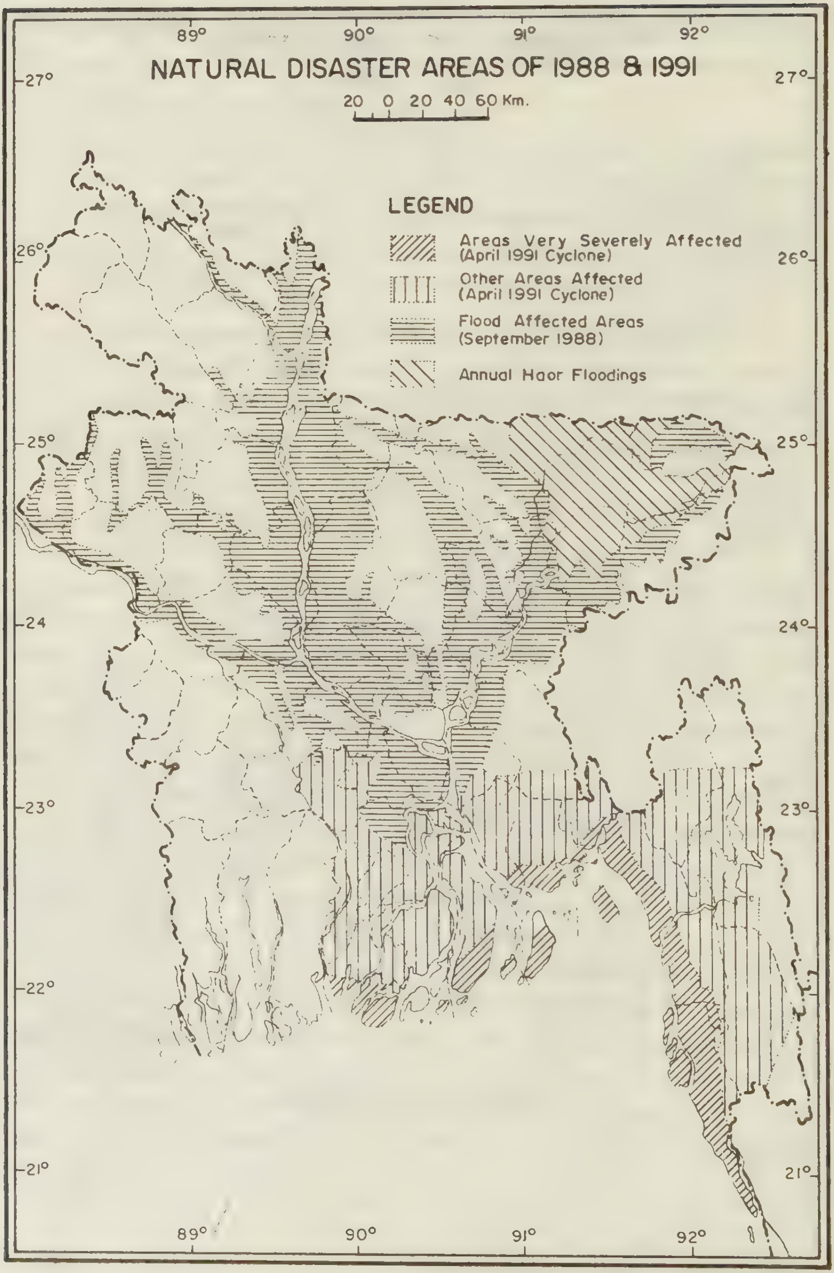
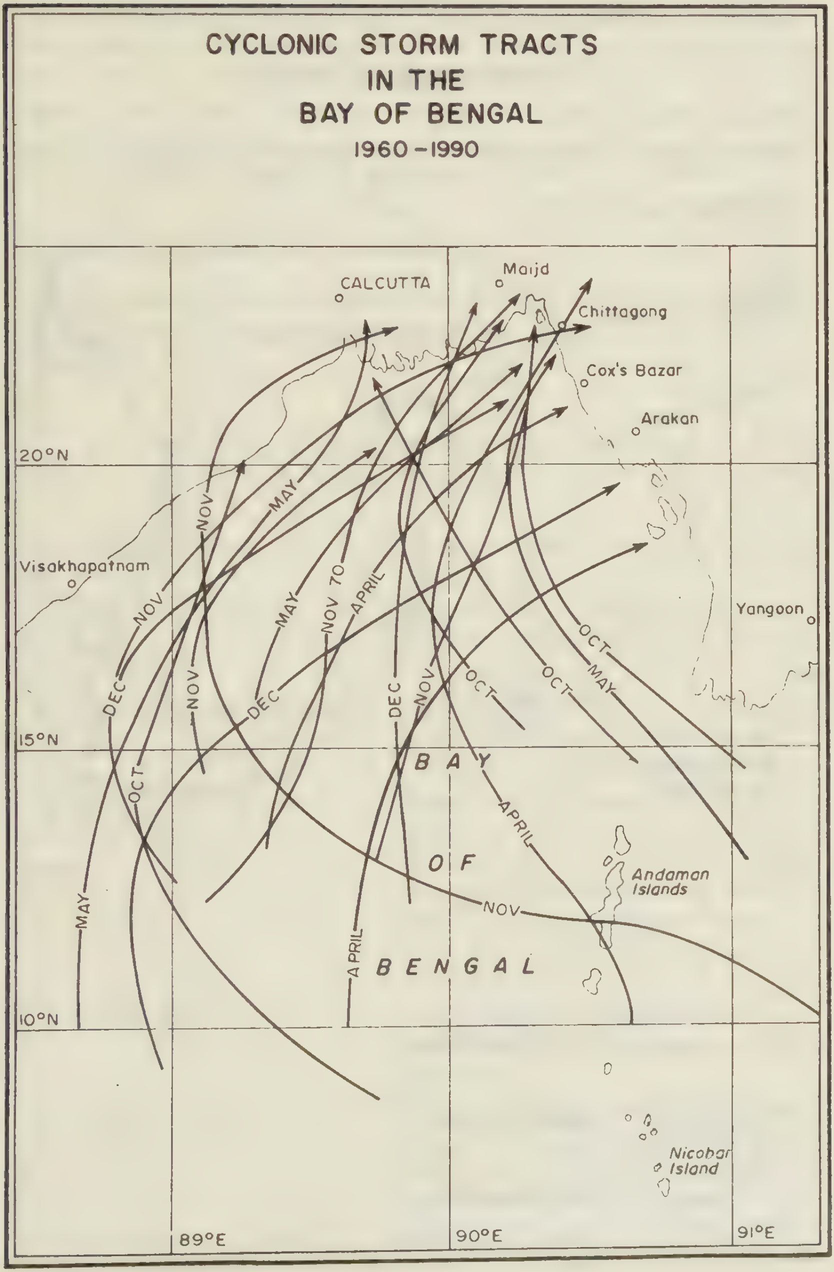
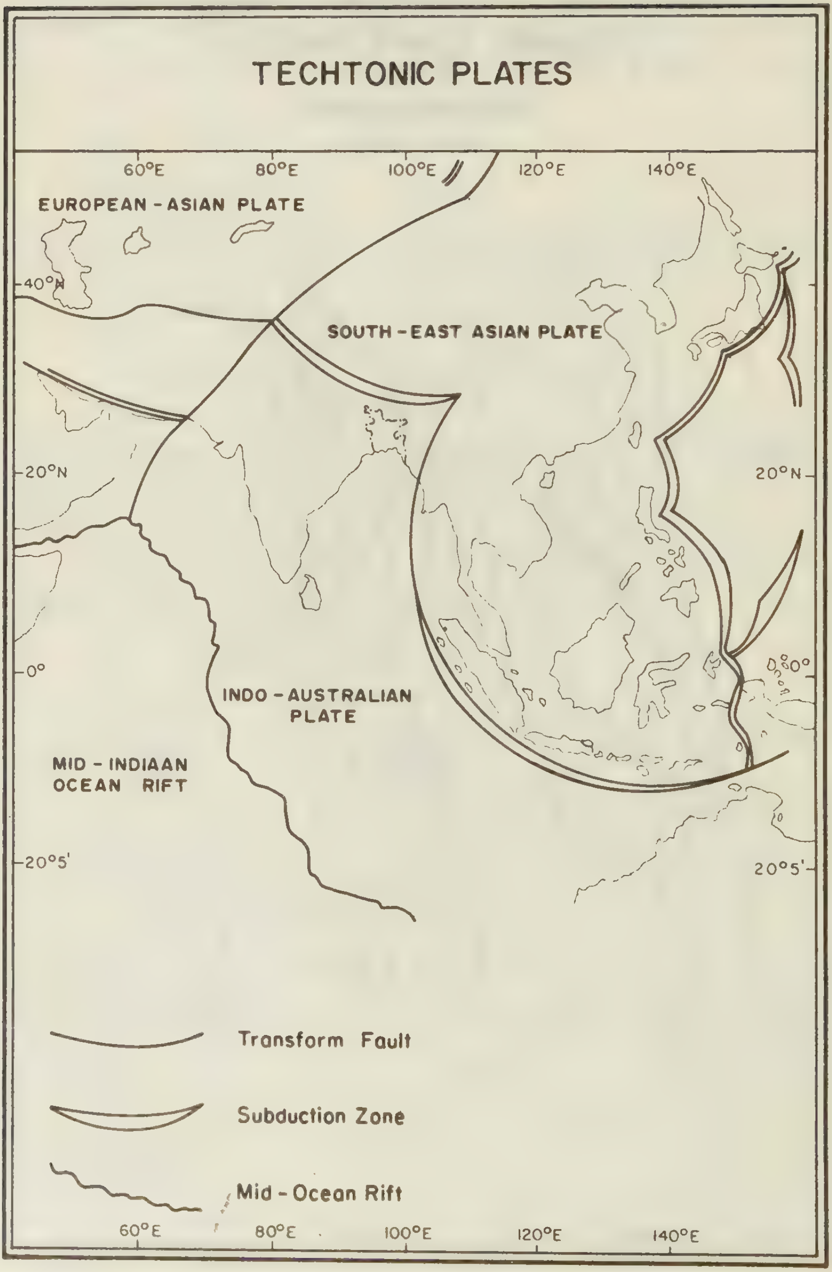

89°
90°
91°
92°
NATURAL DISASTER AREAS OF 1988 & 1991
20 0 20 40 60 Km.
27°
26°
25°
24
23°
22°
21°
LEGEND
Areas Very Severely Affected (April 1991 Cyclone)
Other Areas Affected (April 1991 Cyclone)
Flood Affected Areas (September 1988)
Annual Haor Floodings

Figure 13



CYCLONIC STORM TRACTS
IN THE
BAY OF BENGAL
1960-1990
CALCUTTA
Maijd
Chittagong
Cox's Bazar
Arakan
Visakhapatnam
Yangoon
Andaman Islands
Nicobar Island
BAY
OF
BENGAL
20°N
15°N
10°N
89°E
90°E
91°E
NOV
MAY
NOV 70
APRIL
DEC
OCT

Figure 14


TECHTONIC PLATES
60°E
80°E
100°E
120°E
140°E
EUROPEAN - ASIAN PLATE
40°N
SOUTH - EAST ASIAN PLATE
20°N
20°N
0°
0°
INDO - AUSTRALIAN PLATE
MID - INDIAAN OCEAN RIFT
20°5'
20°5'
Transform Fault
Subduction Zone
Mid - Ocean Rift
60°E
80°E
100°E
120°E
140°E

It should also be kept is mind that the morphology of Bangladesh is extremely fluid and constantly undergoing changes since it is really the outline delta of 3 major rivers. Thus, for example, the changes since the time of Captain Rennell in the eighteenth century (figure 15) have been dramatic. On a smaller scale, it can be seen at the mouth of the river Meghna where the coastline and offshore islands have been changing dramatically over the last two centuries (figure 16).

Areas of Environmental Concerns

It is clear that there are many areas of environmental concern in Bangladesh and some of these have been well described by Rashid, H. 1991 (figure 17) as follows:

Main Areas of Environmental Concern and Their Major Problems

1.	Mahananda Basin	:	Frequently flooded, also subject to droughts.
2.	West-Central Barind	:	Being desiccated through improper land-use. Low water-table and poor soils affect crop agriculture.
3.	Middle Karatoa floodplain	:	Affected by drying-up of the Karatoa river. Double-cropping of HYV Rice has led to severe Sulphur and Zinc deficiencies.
4.	Brahmaputra-Jamuna floodplain	:	Entire stretch affected by Brahmaputra Right Bank Embankment which has been breached 4 out of the last 5 years. The main river may be shifting westwards. Large floating population in the char-lands. Sand-deposits after floods often ruin cultivable land.
5.	Chalan Beel	:	One of the richest wetland areas of Bangladesh, now almost ruined by FCDI projects.
6.	Atrai-Hurasagar drainage basin	:	Due to construction of illconceived embankments and regulators, drainage has been impeded and water-logging has become a serious problem.

Figure 15

Morphological Changes in Bangladesh

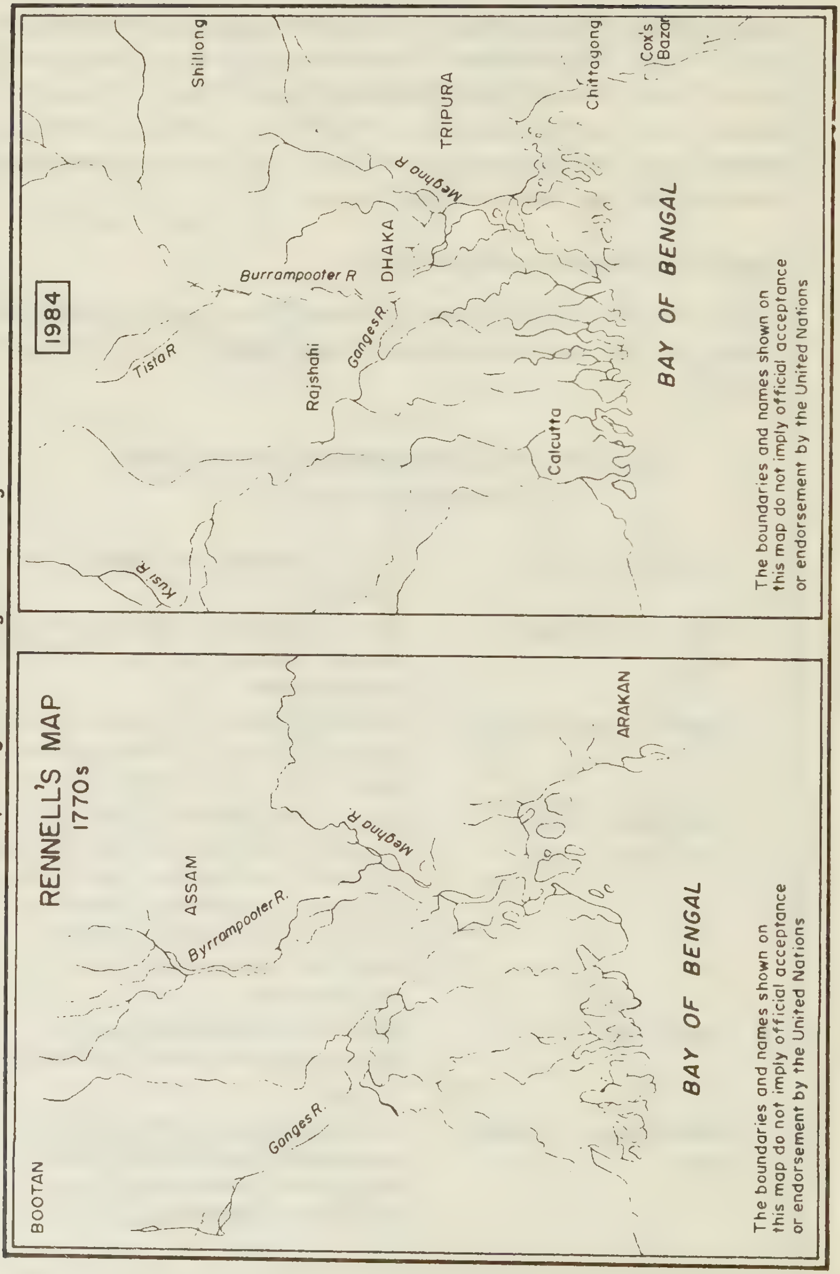
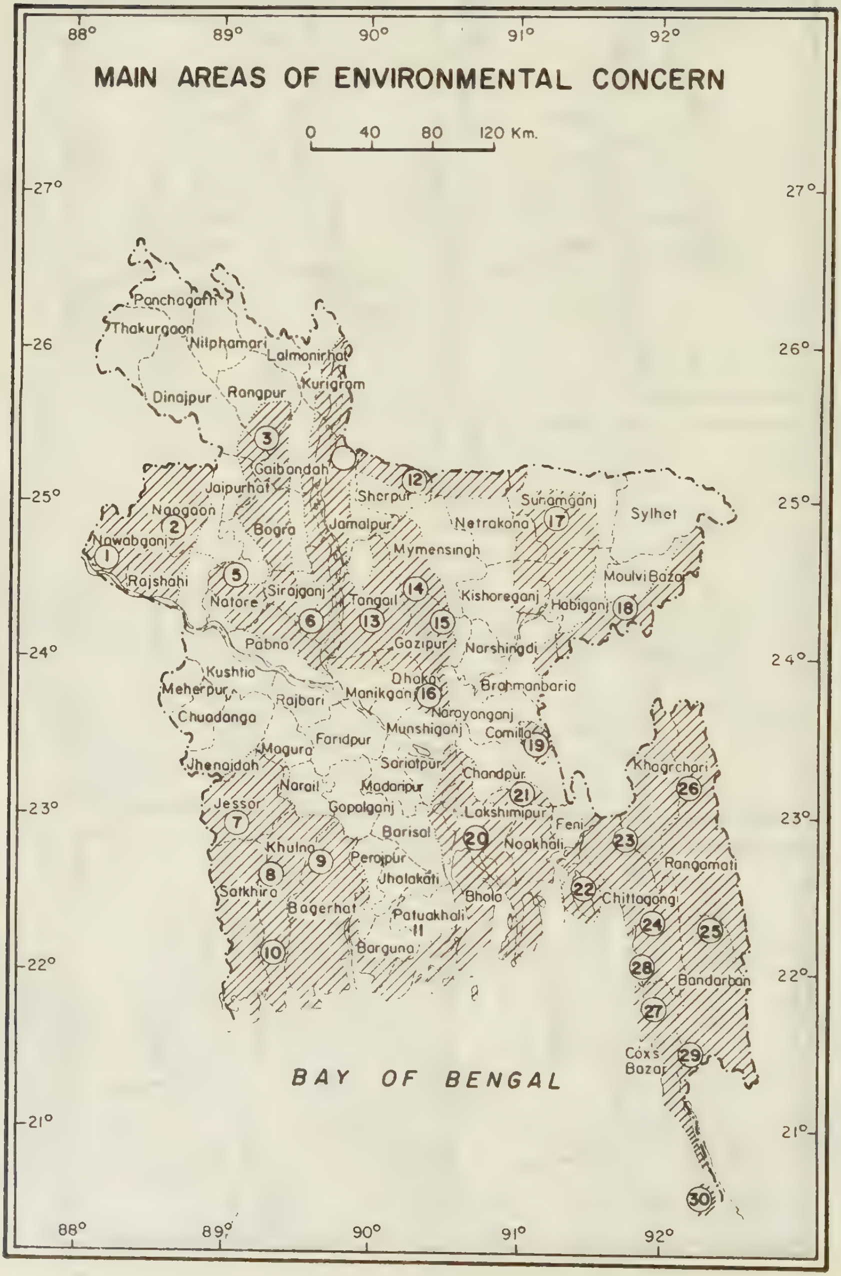


Figure 16

HISTORICAL DEVELOPMENT STAGES OF THE LOWER MEGHNA ESTUARY

Figure 17


MAIN AREAS OF ENVIRONMENTAL CONCERN
0 40 80 120 Km.
88° 89° 90° 91° 92°
27° 26° 25° 24° 23° 22° 21°
Panchagarh
Thakurgaon
Nilphamari
Lalmonirhat
Dinajpur
Rangpur
Kurigram
Gaibandah
Jaipurhat
Naogaon
Nawabganj
Bogra
Rajshahi
Natore
Sirajganj
Pabna
Sherpur
Jamalpur
Mymensingh
Netrakona
Sunamganj
Sylhet
Moulvi Bazar
Habiganj
Kishoreganj
Tangail
Gazipur
Narshingdi
Brahmanbaria
Kushtia
Meherpur
Chuadanga
Rajbari
Manikganj
Dhaka
Narayanganj
Munshiganj
Comilla
Faridpur
Magura
Jhenaidah
Shariatpur
Chandpur
Narail
Madaripur
Gopalganj
Jessor
Lakshmipur
Feni
Noakhali
Khagrchari
Rangamati
Chittagong
Bandarban
Barisal
Khulna
Perojpur
Jhalakati
Satkhira
Bagerhat
Patuakhali
Bhola
Barguna
Cox's Bazar
BAY OF BENGAL
1 2 3 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

7.	South-west Jessore	: This area is climatically subject to wide variations in rainfall and temperature. Due to reduced flow in the Ganges, in the dry season freshwater flow has decreased and salinity has increased.
8.	Northern Khulna	: Large-scale shrimp farming has increased salinity, conflicts among farmers has also reduced rice production.
9.	Khulna City and Mongla town	: Problem area due to industrial pollution, oil spills from ships and urban congestion.
10.	The Sundarbans	: Increased salinity, increasing discharge of ship oil, industrial chemicals etc. has led to the top-dying of several species of trees. There has also been overcutting of the forests for industrial use.
11.	Patuakhali-Bhola-Noakhali Char areas	: Waterlogging, salinity, diluvion exces sive use of pesticide affecting human habitations.
12.	Garo Hills Piedmont	: Erosion, flash floods, loss of tree cover have led to decreasing agricultural productivity.
13.	Tangail	: Silting of rivers, increase in sudden flooding.
14.	Madhupur Tract	: Deforestation and improper use of sloping land has led to topsoil erosion.
15.	Sitalakhya River	: Industrial plants at Ghorashal, Palash and Demra discharge toxic chemicals into this river with loss of fisheries and creation of hazard for public health.
16.	Dhaka City	: Industrial pollution ; urban expansion is destroying Class I agricultural land and some of the best horticultural land in the country.
17.	Haor Basin	: Reduction in fish spawning areas.
18.	South Sylhet	: Affected by deforestation, flash floods and soil erosion.
19.	Lalmai Range	: Deforestation, erosion, soil removal
20.	Lower Meghna	: Affected by floods, erosion, stagnant productivity, loss of fisheries, population pressure.

21.	Central Noakhali	: Water logging in the wet season due to impeded drainage ; lack of irrigation water supply in dry season due to saline ground-water. Decreasing agricultural productivity, increasing population.
22.	Sandwip	: Thickly populated island being eroded rapidly. New land formations not consolidated. Frequently affected by cyclones and surges.
23.	Sitakund Range	: Affected by deforestation, erosion, loss of productivity, major source of thatching grass and therefore, urgently requires Land Use Planning.
24.	Chittagong City and the Port	: Industrial pollution, oil spills, cutting down of hills leading to increasing erosion and consequent silting of rivers.
25.	Chandraghona	: Industrial units discharge large quantities of chemicals into the Karnafuli river, destroying fisheries and posing health hazard.
26.	Hill Tracts	: Slash and burn cultivation (jhoom) and improper use of hill slopes by immigrants have greatly increased erosion and flooding of valleys, with consequent loss of productivity. Serious decline in tree-cover.
27.	Chakaria Sundarban	: A forest area totally destroyed for use as shrimp farms. Now yields are declining and soils are becoming highly acidic.
28.	Chittagong Coast-Kutubdia Island	: Severe bank erosion, loss of land, increase in salinity.
29.	Cox's Bazar	: Tropical moist forests with unique biodiversity being destroyed through clear felling and planting operations, unchecked encroachment and illicit felling of trees.
30.	Jinjira Island and Reef (St. Martins Island)	: Coral reef being destroyed through over exploitation of corals and molluscs.

CHAPTER THREE

ENVIRONMENT AND DEVELOPMENT LINKAGES: AN INTERNATIONAL PERSPECTIVE

Saleemul Huq and A. Atiq Rahman

Historical Background

The awareness of the environment and man's ability to cause it damage began in the developed countries since the fifties of this century. Early warnings of the adverse environmental impacts of human activities were given by such prominent persons as Rachel Carson in her seminal work "Silent Spring" as well as Barry Commoner and Paul Erlich in the United States. They described examples of degradation of the environment from human activities including toxic industrial wastes and pesticides as well as other air and water pollutants which had caused widespread havoc in places like Love Canal and Los Angeles. At the same time, the continuously growing use of non-renewable resources such as fossil fuels, metals and other minerals as well as the growing human population raised fears of the possibility of exhausting the earth's store of such resources. These fears were articulated in the works of the Club of Rome and published in their book "Limits to Growth".

The culmination of these efforts and the widespread realization of the adverse environmental impacts of human activity particularly from industrial and urban wastes led to the first major world conference on the Human Environment in Stockholm in 1972 where heads of states from all over the world came together for the first time to consider the state of the globe as a

whole. This led to the creation of a special agency of the United Nations dedicated to dealing with environmental issues, namely the United Nations Environment Programme or UNEP with its headquarters in Nairobi, Kenya. Since then, UNEP has made major strides in developing worldwide environmental data collection and monitoring of environmental degradation and it has been successful in publishing and disseminating works on global and regional environmental issues. However, it has been less successful in getting any real international or even regional (with honourable exceptions such as the Mediterranean) cooperation of nations on environmental issues.

A particular characteristic of the concern for environmental issues during the sixties, seventies and well into the eighties was that it was very largely confined to the developed countries of the North, while the developing countries of the South were much more concerned with their own development needs and perhaps felt that the environmental problems were associated with highly industrialized countries only. This type of thinking began to change during the eighties as governments and people in the developing countries began to realize that environmental problems are not confined to the industrial societies alone, but they can also occur in less developed societies, often as a consequence of misguided development efforts.

At the international level, this manifested itself in the formation of the World Commission on Environment and Development (WCED) by the United Nations in the mid-eighties which came to be popularly known as the Bruntland Commission after its Chairperson Madame Bruntland, the former Prime Minister of Norway. This Commission with members from both the North as well as the South held a series of public and private consultations with leaders, experts, governments and the people in different regions of the world and published its report called "Our Common Future" which proposed the concept of "Sustainable Development" as a global goal which was defined as allowing development for the present generation without jeopardizing the rights of future generations; in other words, the environment or natural resources should not be over exploited.

Following the Bruntland Commission Report, the issue and concept of Sustainable Development has been adopted by the United Nations as well as most countries including both developed as well as the developing ones and this, in turn, led to the convening of the United Nations Conference on Environment and Development (UNCED).

UNCED

The worldwide concern and awareness of environmental problems and their linkages to development issues led to the UN General Assembly resolution in 1989 to hold a World Conference on Environment and Development in Rio de Janeiro, Brazil in June 1992. This conference, officially called the United Nations Conference on Environment and Development (UNCED) or unofficially the "Earth Summit" came to assume added significance and importance as the preparations began to take shape.

One of the reasons behind this was the very active involvement of the UNCED Secretariat based in Geneva, headed by Maurice Strong, a Canadian businessman who had been a former Director General of UNEP. Together with his multi-national team, Strong organized a series of 4 official preparatory conferences or Prepcoms before June 1992 where all the issues relating to environment and development were raised and discussed. These PrepComs were unprecedented meetings in terms of their openness and accessibility given to a large number of NGOs and other organizations who were given observer status even though the UN member governments were the only official participants.

The other unprecedented aspect of UNCED was the institution of a parallel meeting called Global Forum 92 which was open to everyone including organizations and individuals. There were thus several hundred parallel and separate international and regional meetings held on different aspects in all the continents leading up to UNCED and feeding into the official UNCED process.

The culmination of this remarkable, unprecedented and unique international process in the first two weeks in June 1992 in Rio de Janeiro was, on the one hand, the official UNCED or Earth Summit held in a large Conference Centre about 30 kms. outside Rio de Janeiro with over 110 heads of States or Governments attending including President George Bush (reluctantly) of the United States of America. There, they officially signed four documents which had been prepared and agreed in advance through the PrepCom process namely : (i) The Rio Declaration, (ii) Agenda 21, (iii) The Framework Convention on Climate and (iv) The Biodiversity Treaty (which President Bush refrained from signing). The three major documents are described more fully below.

The other, far more colourful and exciting meeting was held at Flamengo Park in the heart of Rio de Janeiro and had over 30,000 participants from all over the world including both organizations representatives as well as individuals themselves. In the park, there were several hundred booths which any one could rent to display their wares and also 30-40 meeting-rooms or tents which were constantly in use by different organizations and groups holding meetings on different issues. Every evening there was music and entertainment from all over the world in the open air-auditorium. This conglomeration of thousands of people from all countries and all walks of life made UNCED a truly unique and memorable event, different from any other international conference.

The immediate result of both the official and unofficial UNCED was global media blitz taking the message to all corners of the globe via electronic and print media (over 100 TV stations from all the continents covered the event).

In the longer term, in addition to the documents signed at the official conference, it was also agreed to continue the work of UNCED, particularly of seeing to the implementation of Agenda 21 through the creation of a new high powered Council for Sustainable Development to be set up by the UN General Assembly to follow up on the resolutions agreed by all parties at UNCED.

Some of the important documents signed at UNCED are described briefly below.

Agenda 21

The main document prepared by the UNCED secretariat and debated during the Prepcoms was called Agenda 21 which consisted of 40 chapters in four sections coming to a total of over 800 pages of text. Some of the most significant issues raised are the following:

- International cooperation to accelerate sustainable development in Developing Countries (Section I, Chapter 2).
- Poverty (Section I, Chapter 3).
- Consumption Patterns (Section I, Chapter 4).
- Demographic Dynamics and sustainability (Section I, Chapter 5).

- Protection and Promotion of Human Health (Section I, Chapter 6).
- Promoting Sustainable Human Settlements (Section I, Chapter 7).
- Policy-making for Sustainable Development (Section I, Chapter 8).
- Protecting the Atmosphere (Section II, Chapter 9).
- Land Resource Use (Section II, Chapter 10).
- Conservation and Rational use of Forests (Section II, Chapter 11).
- Halting the Spread of Deserts (Section II, Chapter 12).
- Protecting Mountain Ecosystems (Section II, Chapter 13).
- Meeting Agricultural Needs Without Destroying the Land (Section II, Chapter 14).
- Sustaining Biological Diversity (Section II, Chapter 15).
- Environmentally Sound Management of Biotechnology (Section II, Chapter 16).
- Safeguarding the Ocean's Resources (Section II, Chapter 17). Protection and Management of Freshwater Resources (Section II, Chapter 18).
- Safe Use of Toxic Chemicals (Section II, Chapter 19).
- Managing Hazardous Wastes (Section II, Chapter 20).
- Seeking Solutions to Solid Waste Problems (Section II, Chapter 21).
- Management of Radioactive Wastes (Section II, Chapter 22).
- Action for Women : Sustainable and Equitable Development (Section III, Chapter 24).
- Social Partners for Sustainable Development (Section III, Chapter 25-32). These include Youth (Chapter 25), Indigenous People (Chapter 26), NGOs (Chapter 27), Local Authorities (Chapter 28), Workers and Trade Unions (Chapter 29), Business and Industry (Chapter 30), Scientific and Technological Community (Chapter 31) and Farmers (Chapter 32).
- Financial Resources and Mechanisms (Section IV, Chapter 33).
- Making Environmentally Sound Technology (Section IV, Chapter 34).
- Science for Sustainable Development (Section IV, Chapter 35).

- Promoting Environmental Awareness (Section IV, Chapter 36).
- Building National Capacity for Sustainable Development (Section IV, Chapter 37).
- Strengthening Institutions for Sustainable Development (Section IV, Chapter 38).
- International Legal Instruments and Mechanisms (Section IV, Chapter 39).
- Bridging the Data Gap (Section IV, Chapter 40).

Each of the chapters lists the major issues being faced in implementing action programmes by international and regional organizations, governments, NGOs and other communities and groups. In some cases, cost estimates for proposed actions are also included.

Climate Convention

Although the Climate Convention was signed by the Heads of State and Ministers from over 150 countries at Rio de Janeiro during UNCED in June 1992, its genesis and development had been a separate process, different from the UNCED process itself.

The fact that certain gases in the atmosphere trap the sun's radiation and thus cause the earth's atmospheric temperature to be higher than it would otherwise be, has been known since the time of the Swedish scientist Arrhenius in the 19th century. This atmospheric warming effect is similar to that which occurs in a greenhouse and hence the name "Greenhouse Effect" and the gases responsible for the effect (mainly carbon dioxide, methane, water vapour and chlorofluorocarbons) are known as "Greenhouse Gases". However, it was only in the last decade that actual measurements of global temperatures when correlated with powerful computer models of the atmosphere called Global Circulation Models (GCMs) started predicting that we may be entering a period of a runaway greenhouse effect which would have drastic consequences in the next century unless action was taken soon to prevent it from happening.

This concern was first raised by the scientists in the eighties at such conferences like Bellagio and others which caused the UNEP and the World Meteorological Organization (WMO) to jointly set up an Intergovernmental

Panel on Climate Change (IPCC) consisting of over 200 of the world's leading scientists to examine the best scientific evidence available and reach a consensus on the seriousness of the issue.

The IPCC was, perhaps, one of the most thorough exercises in soliciting and bringing together the best scientific evidence on all aspects of climate change available amongst the scientists from all over the world and the Final Report was presented at the Second World Climate Conference held in Geneva in 1989 where the world's leading scientists unanimously expressed their concern about the dangers of climate change and recommended political action. This message was clearly taken seriously by the political leaders present at the conference and they directed the United Nations (through the General Assembly) to start immediately an Intergovernmental Negotiating Conference (INC) to prepare a Framework Convention on Climate Change to be ready for signing during UNCED in June 1992.

The INC process went through 5 different meetings held every few months in Geneva, Nairobi and New York and was participated by all the member states of the United Nations and was finally able to agree to a Framework Convention at a special sixth session held just before UNCED where all parties agreed to the Draft Convention following intense lobbying and persuasions.

The Framework Convention includes a number of sections including the objective which is "to achieve, in accordance with the relevant provisions of the Convention, stabilization of Greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference in the climate system." This is followed by a statement of Principles and Commitments which are divided between the developed and the developing countries with special emphasis on the need to prevent adverse impacts on small island countries, countries with low-lying coastal areas, countries with arid and semi-arid areas and forested areas, countries prone to natural disasters, countries liable to drought and desertification and countries with high urban atmospheric pollution. Other Articles dealt with Research and Systematic Observation, Education, Training and Public Awareness and Financial Mechanisms.

During the negotiations, the two most controversial sections were on commitments where the developing countries pushed for strong commitments from the developed countries to stop any increase in greenhouse gas emissions as they were the main contributors, and the Financial

Mechanisms where the need for massive transfers of funds were recognized but firm commitments were lacking.

The final Framework Convention was thus a toothless and watered down document without any clear guidelines for stopping greenhouse gas emissions or for genuine transfer of technologies or resources.

However, it is expected that the actual protocols to be negotiated subsequently under the Framework Convention will possibly be more hard-hitting. In any case, the process of negotiations continues under the Framework Convention.

One of the useful features of the INC process was the input from the scientific community and the NGOs, often working very closely together. Although the actual negotiations under INC were carried out by the official country delegations, the negotiators had allowed the NGOs and the scientists observer status, also allowing them to address each INC's concluding session. Some countries had also included NGOs as members in their delegations and the NGOs were thus able to lobby and influence the actual negotiations taking place. This resulted in a good working relationship between the government delegates, NGOs and the scientists interested in climate change related issues.

Convention on Biological Diversity

This was the second convention to be agreed and signed by almost all the Heads of States in Rio (with the exception of the United States of America). It obliges the signatory nations to protect the biological diversity within their boundaries and also allows for international funding for this purpose.

The Convention itself has a number of sections with the objectives being "the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources." Further sections cover cooperation, identification and monitoring, in-situ conservation, ex-situ conservation, sustainable use of components of biological diversity, incentive measures, research and training, public education and awareness, impact assessment, access to genetic resources, access to and transfer of technology, exchange of information, technical and scientific cooperation, handling of biotechnology and distribution of its benefits, financial resources and financial mechanisms.

The most controversial issues dealt with access to genetic resources and the issue of patenting biotechnology based on genetic biodiversity as well as funding mechanisms. These issues were finally resolved at the final negotiating meeting held in Nairobi just before UNCED but the United States, after initially agreeing with them brought up some additional objections and therefore, President Bush refused to sign the Convention during UNCED. Nevertheless, it was signed by most of the other heads of states including those of Europe and Japan so it had the support of the vast majority of countries.

Funding Mechanisms

Throughout the debates on the Climate Convention, the Biological Diversity Convention and Agenda 21, there had been a running debate on the need for additional funding over and above the existing aid which has been a demand of the South led by the Group of 77. The North, led by the Group of 7 on the other hand, has been extremely reluctant to commit any new funding or allow any new funding mechanisms or organizations. The resulting compromise has been the creation of a hybrid entity called the Global Environmental Facility jointly organized by the World Bank, UNEP and UNDP with the Bank acting as the Secretariat. The main areas of its operation have been very limited so far. For example, at present it funds projects limited to one of the following four areas only :

- Global Climate Change
- Biodiversity
- International Waters
- Ozone layer depletion.

The manner in which the projects have been selected, funds have been allocated and disbursed has also raised criticism as there has been hardly any open discussion at all. The whole programme is being run out of the World Bank funds in Washington DC and even the partner organizations, UNEP and UNDP are feeling that they are not being consulted sufficiently.

During the various discussions and debates on funding mechanisms, the developing countries, therefore, strongly objected to the GEF being the sole vehicle for financing environmental projects. However, the developed

countries, whose views eventually prevailed, preferred the GEF to be the sole funding vehicle.

However, the developing countries managed to get some concessions about the inclusion of more areas for funding (starting with desertification) and more openness and transparency in the governance of the organization and its activities, particularly regarding the selection of projects for funding.

North-South Debate

One major result of the process of international discussion on environment and development linkages which had been considerably hastened by UNCED has been the North-South debate on population and consumption. The North has consistently targeted and blamed population increases in the developing countries as a major threat to the global environment whereas, the south has countered by showing that it is not the number of people in a given country that governs the levels of global environmental damage but rather the per capita consumption of its citizens is a much more direct factor. Thus, for instance, the average per capita energy consumption and hence greenhouse gas emissions in the developed countries is many times higher than those in the developing countries and hence the responsibility of the developed countries to mitigate the effects is much higher.

This debate has now led to a questioning of the entire development paradigm itself, since it is patently evident that the earth's existing resources and carrying capacity would not allow for all the citizens of both developed as well as the developing countries to have the same levels of energy consumption and waste as the developed countries. It is, therefore, necessary for the development practitioners, both national and international to re-think what development is all about and see whether there are alternative paths to the ones we have so blindly been following for the past decades.

Sustainable Development: The Future

The sustainability of the earth and its people in the next century and millenia will, therefore, depend on our finding solutions to this paradigm. It will be necessary to find ways of alleviating the abject poverty in which a fifth of humanity is living while not taking the path of increasing and wasteful consumption. At the same time, the extremely wasteful

consumption patterns of the developed countries need to be dealt with as a global environmental concern so that "development" may be separated from "wasteful consumption". This will require that all human beings on this planet come to regard themselves as global citizens rather than simply citizens of one country or community. This may seem a difficult and almost impossible task but it is essential if the world is to achieve sustainable development for all its inhabitants.

CHAPTER FOUR

ENVIRONMENTAL ACTIVITIES IN BANGLADESH

Saleemul Huq and A. Moyeen Khan

Introduction

Environment has become a major concern, both at the global level as well as at the national level in the developed and developing countries of the world, particularly, within the last few years. This is exhibited in the increasing concern about aspects like the Greenhouse Effect with the consequent increase in sea level, which may inundate large parts of the low lying deltaic regions of the world including Bangladesh.

Acid rain as well major accidents like the nuclear fallout from Chernobyl in the USSR also raise environmental concerns across national boundaries. Similar accidents, like the one in Bhopal, India have raised public consciousness about environmental issues to a national level.

In the less developed countries, including Bangladesh, such concerns until very recently were regarded either as issues of concern for the developed countries alone, or as long-term issues for which present day resources need not be committed, since we are facing much greater immediate crises. This attitude has changed considerably in the last few years and a number of initiatives have been launched at the government as well as the non-government and public consciousness level.

This paper attempts to summarize the various activities in the fields of environment that have been and are currently taking place in the country including activities by the government, non-government, academia, donors and media. The survey is not exhaustive but gives a flavour of the type of activities being carried out by the different actors.

Government Sector Activities

Ministry of Environment and Department of Environment

Until very recently, the only government agency dealing specifically with environmental matters, or having the word 'Environment' in its title was the Department of Environment and Pollution Control (DEPC). This Department was under the Ministry of Local Government and Rural Development (LGRD) and employed a relatively small number of engineers and chemists who carried out studies on pollution due to industries and also air pollution due to vehicle emission. They also would undertake pollution abatement measures in some specific cases. They had branch offices in Chittagong, Khulna and Bogra for carrying out pollution monitoring activities throughout the country.

The DEPC was also designated as the government agency for liaising with the United Nations Environment Programme (UNEP) and was the national agency participating in global programmes such as GEMS.

The major problems DEPC faced were:

- Although it was given responsibility for almost all environmental sector activities, its' remit was to deal with environmental pollution only. This was a major restriction on its functions.
- It's attachment to the Ministry of LGRD was perhaps not appropriate.
- Even when sources of industrial pollution were clearly identified, the DEPC found itself very much a weaker adversary in any confrontation with the industries concerned and
- The Department was possibly undermanned and underfunded, particularly, if it was to play a role beyond merely pollution monitoring.

Considering the above problems and in view of the importance of environment as a cross-sectoral issue, a number of scientists, non-government organizations and others had been advocating the creation of a Department of Environment and even if necessary, a Ministry of Environment. In August 1989, therefore, the Government of Bangladesh created a new Ministry of Forests and Environment which incorporated the Department of Forests (previously under the Ministry of Agriculture and Forests) and created a new Department of Environment, based on the old DEPC, but with greatly expanded terms of reference and manpower.

This act at once elevated environment as an issue within the government, with a Minister now responsible for the subject. The Ministry and Department are now in the process of preparing and implementing their manpower development programme. They also developed an Environmental Policy and Environment Action Plan which was approved by the Cabinet and Prime Minister in April 1992.

Department of Environment (DOE)

Before the creation of the DOE, the Asian Development Bank had agreed to fund a project to strengthen the erstwhile DEPC in its manpower and technical capabilities. This entailed recruitment and training of more technical manpower, development of better laboratory and analytical facilities and construction of new laboratory and office buildings in Dhaka. The project had provision for expert expatriate consultancy services. Since the beginning of the project, the DEPC has been transformed into the DOE and the consultants expanded their advisory services to cover other issues regarding strengthening of the capabilities of the DOE. The Department has greatly expanded its manpower and has begun to carry out activities beyond its earlier parameter which were confined to pollution control.

National Conservation Strategy (NCS)

The International Union for the Conservation of Nature and Natural Resources (IUCN) based in Gland, Switzerland developed a World Conservation Strategy and has also prepared a number of National Conservation Strategies (NCS) in countries such as Zambia, Nepal and Madagascar. In 1986, a seminar on Conservation and Development was held in Dhaka jointly by IUCN and the Bangladesh Centre for Advanced Studies (BCAS) a private, non-profit scientific research organization which recommended that a National Conservation Strategy be prepared for Bangladesh. Following the seminar, the Government of Bangladesh convened an 18 member interministerial committee chaired by the Minister for Agriculture and Forests which recommended that a Prospectus for the NCS be prepared. Accordingly, the prospectus was prepared in 1987 with the assistance of IUCN and input from BCAS while the Bangladesh Agricultural Research Council (BARC) acted as the secretariat. The second phase of

the NCS was completed in 1991 resulting in the National Conservation Strategy Document.

Coastal Environment Plan

In 1987, a study of the Coastal Environment of Bangladesh was carried out under the aegis of the Economic and Social Council for Asia and Pacific (ESCAP), a United Nations agency based in Bangkok, Thailand. They engaged a number of eminent experts in different fields to prepare sector reports on different aspects of the coastal areas of Bangladesh. These were then compiled into a publication on the Coastal Environment which was published by ESCAP. This includes sections on mangrove forests, fisheries, land and water development projects, biocides, environmental health and sanitation, biomass crisis, industrial and marine pollution and tourism.

Inland Water Fisheries Resources

A major recent initiative in the natural resource sector has been the New Fisheries Policy (NFP) of the government where the critical issue hovers around the survival in Bangladesh inland waters of a large number of fresh water fish species and the sustainability of these fisheries resources. While no concrete studies were made in the past in Bangladesh, a beginning has been made by the Ministry of Fisheries and Livestock (MOFL) in collaboration with a group of experts from Bangladesh, organized by BCAS and abroad, organized by the International Centre for Living and Aquatic Resources Management (ICLARM). The experts conducted studies in this field and indicated recommendations to the government to take appropriate remedial measures to arrest this situation. This led to the creation of the New Fisheries Management Policy and projects to restock the flood plains.

Flood Action Plan

Following the devastating floods of 1988, the Government of Bangladesh together with a consortium of donors led by the World Bank, prepared a Flood Action Plan incorporating 26 different components to combat the vagaries of floods in Bangladesh. Studies under this project have been on-

going since 1990 and a number of projects are scheduled for implementation in the near future. The Flood Action Plan raised controversies from its very inception, particularly, regarding its environmental aspects. These are dealt with in greater detail elsewhere in the book.

Other Government Agencies

In addition to the Ministry and Department of Environment, a number of other government agencies deal with aspects of environmental issues. These include the Department of Forests, the Space Research and Remote Sensing Organization, the Bangladesh Agricultural Research Council and its affiliated research institutes, the Water Development Board, the River Research Institute etc. Table 1 shows the main agencies with their affiliating Ministry and main area of activity.

Academia

Environmental Education in Universities

None of the universities of the country, located in Dhaka, Chittagong and Rajshahi nor the Bangladesh Agricultural University have any formal Departments or programmes in Environment. However, they have Departments of Botany, Zoology, Soil Science and Chemistry.

The Bangladesh University of Engineering and Technology (BUET) runs a course in Environmental Engineering which caters mainly to Public Health Engineering requirements. They also have a strong programme in the Department of Water Resource Engineering.

Jahangirnagar University: Jahangirnagar University has recently started an Institute of Life Sciences. It is also running a course in Environmental Chemistry in the Department of Chemistry.

International Institute for Environmental Studies and Disaster Management (IIESDM) This international institute was set up in 1989 following the recommendations of the International Seminar on Floods: Global, Regional and National Perspectives. It has six programmes on environmental aspects of floods and other natural hazards.

Table 1

Principal Government Institutions Involved in Some Aspects of Environmental Issues

Organization	Full Name	Parent Ministry	Nature of work
BADC	Bangladesh Agricultural Development Corporation	Ministry of Agriculture and Irrigation	Data collection on ground water
BAEC	Bangladesh Atomic Energy Commission	Ministry of Energy	Research on uses of atomic energy
BARC	Bangladesh Agricultural Research Council	Ministry of Agriculture	Coordination of agricultural research
BARI	Bangladesh Agricultural Research Institute	Ministry of Agriculture	Agricultural research
BBS	Bangladesh Bureau of Statistics	Ministry of Planning	Statistical data collection
BFRSS	Bangladesh Fisheries Resource Survey System	Ministry of Fisheries	Collection and dissemination of fish catch data
BCSIR	Bangladesh Council for Scientific and Industrial Research	Ministry of Industries	Applied industrial research
BJRI	Bangladesh Jute Research Institute	Ministry of Agriculture	Research on improving jute production
BIDS	Bangladesh Institute for Development	Ministry of Planning	Research and publications on development economics
BMO	Bangladesh Meteorological Organization	Ministry of Defence	Weather data collection
BRRI	Bangladesh Rice Research Institute	Ministry of Agriculture	Research on rice production
BTRI	Bangladesh Tea Research Institute	Ministry of Agriculture	Research on tea production
BWDB	Bangladesh Water Development Board	Ministry of Water Resources	Data collection on river
DOF	Department of Forests	Ministry of Environment and Forests	Management of forestry resources
DOF	Department of Fisheries	Ministry of Fisheries and Livestock	Management of fisheries
FRI	Forest Research Institute	Ministry of Environment and Forests	Research on forestry
FRI	Fisheries Research Institute	Ministry of Fisheries and Livestock	Research on fisheries production
GSB	Geological Survey of Bangladesh	Ministry of Energy	Geological data collection
LRI	Livestock Research Institute	Ministry of Fisheries and Livestock	Research on livestock production
MPO	Master Plan Organization	Ministry of Water Resources	Data collection on water resources
PI	Petroleum Institute	Ministry of Energy	Training and research on geology
PC	Planning Commission	Ministry of Planning	Publication on planning of economy
RRI	River Research Institute	Ministry of Water Resources	Research on river dynamics
SPARRSO	Space Research and Remote Sensing Organization	Ministry of Defence	Data collection from satellites

NGOs

Bangladesh has about 10,000 NGOs, ranging from the very small to the very big in a wide variety of areas. A number of NGOs have been active in environmental issues in the last few years. It is perhaps useful to divide them into several categories with respect to their main activities such as:

- Research NGOs
- Awareness/Media NGOs
- Activist NGOs and
- Development NGOs

Some of the leading examples from each type are described with the acknowledgement that the list is not complete and the examples are provided as an illustration and not as an exhaustive listing.

Research NGOs

Bangladesh Centre for Advanced Studies (BCAS): This is one of the oldest NGOs working in the field of environment. Its main programme is called Natural Resources, Environment and Development under which it has a number of projects in the fields of agricultural development, surface water systems, social forestry, fisheries, urban health and global climate change. It is also the secretariat and implementing agency for the State of the Environment Report (SOER). The purpose of the organization is to harness Bangladeshi and international expertise to develop suitable scientific methodologies for carrying out multidisciplinary research on resource management, environment and development issues. It has held a number of seminars and workshops and has also published several books and reports on environmental issues. It brings out a number of quarterly Newsletters on environmental issues and activities.

International Institute for Environmental Studies and Disaster Management (IIESDM): This Institute was set up in 1989 following an International Seminar on Floods held in Dhaka. It is governed by an international Board of Advisers headed by Professor Abdus Salam, the Nobel Laureate. The Institute has taken up six scientific research programmes in areas related to environment and disaster management. It also publishes a quarterly

journal, "Bangladesh Quest" containing scientific articles by eminent scientists.

International Union for Conservation of Nature (IUCN): This is an international NGO involved in studying, collecting and preserving threatened natural habitats, ecosystems and species around the world. It has developed a World Conservation Strategy and also a series of National Conservation Strategies (NCS) for countries such as Zambia, Nepal and Pakistan. In 1987, it organized a seminar jointly with BCAS on "Conservation and Development" which recommended the preparation of a NCS for Bangladesh.

Subsequently, the Government decided to prepare the NCS, a task carried out by the Bangladesh Agricultural Research Council with support from IUCN. In addition to the NCS, IUCN has also developed a number of projects in Bangladesh which include environmental awareness raising, enhancement of the Botanical Garden and National Herbarium and development of plans for protecting and managing threatened natural habitats.

Multidisciplinary Action Research Centre (MARC): This organization is currently undertaking a number of environment related programmes, including an awareness creation programme and a natural resource information centre. It also has undertaken surveys of flora, fauna and land resources in parts of the country.

National Oceanographic qnd Maritime Institute (NOAMI): The organization is primarily involved in oceanographic and maritime activities. It also has a programme on the country boats of Bangladesh, including their design, navigation and socio-economic characteristics.

Ubinig: This organization conducts studies as well as action research on a number of primarily, development related issues such as women, health and technology. It has also done work on environment related issues including the issue of toxic waste disposal, social forestry issues and shrimp seed collection. It also has some publications.

Winrock International: This is an international NGO based in USA and involved in Bangladesh, primarily in developing agro-forestry programmes with the government as well as the NGOs. It has supported studies on participatory social forestry activities by NGOs as well as other groups in different parts of the country.

Awareness/Media NGOs

Forum of Environmental Journalists (FEJ): This organization consists of a group of journalists interested in environmental issues. It was created under the aegis of the UN Economic and Social Council for Asia and Pacific (ESCAP) based in Bangkok. It has held workshops and demonstrations to highlight environmental problems such as spraying of pesticides in Dhaka.

Centre for Sustainable Development (CSD): The organization was started by some journalists with the intention of disseminating environmental information and stories to the media and also through their own publications. They have also undertaken training of local journalists on environmental issues.

Society for Conservation of Nature and Environment (SCONE): This organization consists mainly of environmental activists and wildlife lovers whose main activity is to produce a monthly journal on environmental issues which is supported by the Ministry of Science and Technology.

Institute for Environment and Development Studies (IEDS): This is the Bangladesh Chapter of the Friends of the Earth, an international environmental NGO. It is involved in raising environmental issues through the publication of a Bulletin. It is based in Chittagong where it has a membership largely consisting of journalists and environmental activists.

Activist NGOs

Pothikrit: This organization is based in Chunati, about 40 km. south of Chittagong next to a wild game sanctuary. It consists of a group of nature lovers who have been trying to protect the wild game reserve, which is home to a large number of wild animals including elephants, now threatened by deforestation and encroachment. In 1989, they held a seminar in Chittagong, jointly with BCAS and the Department of Forests, to highlight the problem of deforestation and subsequently, they have undertaken reforestation programmes in the area as well as environmental education and awareness raising amongst the local people.

Barind Protection Society: This consists of a group of journalists, teachers, academics and environmental activists based in Rajshahi who are concerned

about the degradation of the Barind Tract in the north-western part of the country which is a distinct ecosystem with perhaps the driest conditions in the country. They raised concerns about loss of tree cover, decreasing levels of surface water and the perceived threat of desertification in the region. They have held seminars and brought out publications to highlight the problems.

Coastal Area Resources Development and Management Association (CARDMA): This organization consists of representatives from the coastal districts. They are primarily concerned with development of the coastal areas but also have an interest in environmental and resource management issues. They publish a Bengali publication entitled "*Paribesh*" (Environment).

Development NGOs

These cover the majority of NGOs ranging from the very small to the very large and many of them have similar types of environment related activities such as tree planting, aquaculture, poultry, health and sanitation. Only a few select NGOs are listed below to provide an illustration of the main types of activities. The list is nowhere near exhaustive and definitely does not include many other NGOs also doing similar work.

BRAC: This is one of the oldest and biggest NGOs in the country. Its activities range from group formation, credit, poultry, aquaculture, education to health and sanitation. A few of its environmentally relevant activities include support for tree plantation by group members, technical support for aquaculture and poultry raising, training and awareness creation on oral dehydration for diarrhoeal diseases and immunization.

Proshika: This is also one of the larger development NGOs which has perhaps one of the most remarkably successful programmes on tree planting by their groups on roadsides, embankments and other public lands. They also have groups living in and near the forests and have actively protected the forests from being cut. They are also engaged in planting trees. These are some excellent examples of people's initiatives in protecting their own environment.

Grameen Bank: Although primarily a bank, it may nevertheless be considered a development NGO, as its target groups are also the rural poor. It has entered into a major natural resource development area by taking over a large number of the government's fish seed multiplication farms from the

Department of Fisheries. It plans to develop these facilities for the benefit of its target groups. Grameen Bank has also taken over some deep tubewells for the same purpose. These examples represent a novel approach in involving the rural poor in managing some of the rural natural resources.

Ganoshasthyo Kendro (GK): Although primarily involved in running primary health care programmes for the rural poor, GK has also diversified into the manufacture of generic medicines and has established a garden of medicinal plants with over two hundred species of indigenous plants which have been used in traditional medical applications. GK is now moving towards clinical trial of some of the most promising of these traditional medicinal plants. This is the first time that the country's traditional knowledge and natural resource (medicinal plants) have been systematically preserved and utilized.

Association of Development Agencies of Bangladesh (ADAB): In its capacity as an association of NGOs, it carries out a number of programmes to facilitate the development of networks. In particular, it has developed a network of NGOs working on social forestry issues, including tree planting, agro-forestry, forest protection, etc. It is also developing a similar network on environmentally related NGOs and is planning to develop training materials.

Voluntary Health Services Society (VHSS): This is a similar grouping of health sector NGOs which is also planning to enhance its activities in the environment sector. It held a workshop on "Environment and Health" jointly with BCAS, as a way to identify future activities in this sector.

Hellen Keller (HK): This international NGO has been active for many years in promoting greater nutritional awareness in order to increase the dietary intake of vitamin A rich food as a means of preventing blindness.

Christian Community for Development in Bangladesh (CCDB): This is one of the major development NGOs, working in a number of sectors with the rural poor as its target group. As with many other development NGOs, it trains its own trainers in a package of different subjects including leadership development, credit, hygiene, etc. It has developed a training module together with BCAS, for training its trainers in environment related issues. The training has been successfully imparted to about 30 trainers who in turn have imparted training to over a thousand people in their target groups. A

simple manual is being developed for such training to be given to other NGOs.

South Asia Partnership (SAP): This international NGO is primarily a conduit for arranging funding from Canadian NGOs to NGOs in the countries of South Asia, including Bangladesh. It undertook a review of NGOs and the environment in each of the countries of South Asia. *Environment Sector Review* by S.I. Ali and W. Zaman, looked at a wide range of NGOs and their environment related activities. The authors also interviewed a number of NGO personnel at their head office as well as grass-root workers and also some of the group members to ascertain the level of their knowledge and perceptions on environmental issues. The report is expected to be published by SAP.

Some Recent NGO Initiatives in Environment

As will be apparent from the list of some of the NGOs active in environmental activities, there is much being done by particular NGOs. However, in recent times, there have also been a number of initiatives taken by groups of NGOs in the environmental sector.

State of the Environment Report (SOER): This initiative involves a group of national NGOs including BRAC, BCAS, GK, Proshika, Proshika-Comilla, Grameen Bank, ADAB, VHSS, Caritas and CCDB which have elected BCAS as its secretariat to develop a methodology and prepare a Citizen's Report on the Environment. The objective is to determine people's own perceptions, ideas and solutions about environmental problems and issues and produce a report to be published in both Bengali and English for widespread dissemination.

The project is funded entirely from core funds of the participating NGOs, as no foreign funding has been accepted as a matter of principle. The project has developed a list of generic issues (such as loss of soil fertility, population, etc.) and geographic issues (such as the Sundarban, Barind, Chittagong Hill Tracts, etc.) which have been addressed through a series of regional workshops involving local people, NGOs, government officials, experts and media representatives. Three such regional workshops were held in Chittagong, Rajshahi and Khulna and others are planned in Sylhet, Dhaka and Mymensingh. This report will be available in 1992.

Agitation about Hazardous Waste: In 1989, there was a major effort by certain quarters to get the Government of Bangladesh to allow the import of waste from the United States under the guise of raw material for producing cheap energy for a proposed chemical industry to be located in Chittagong. The process advanced considerably when a section of journalists, academics and NGOs began to voice their grave concerns about the possibility of allowing hazardous wastes to be imported under this pretext. This led to considerable agitation and media reporting backed by NGOs, which eventually caused the government to reconsider the matter. Permission was eventually not granted. This exercise is a useful example of NGOs, academics and media working together to raise concerns about an environmental issue and having an impact.

Donors

A number of bilateral and multilateral donors have also taken greater interest in environmental issues in recent years. These have mostly been initiated due to environmental concerns in home countries or headquarters rather than in the Bangladesh office. A number of donors have initiated assessments of environmental issues in Bangladesh, as well as environmental aspects of their own development strategies in Bangladesh. Some have published their findings. These include:

- DANIDA which carried out an environmental assessment and published an Environmental Profile of Bangladesh in 1990.
- NORAD who carried out an environmental assessment of their development strategy in Bangladesh in 1990.
- USAID who also carried out an environmental assessment by the World Resources Institute which was published as Environment and Natural Resource Assessment of Bangladesh in 1991.
- The World Bank which brought out a report on Bangladesh Environment Strategy Report in 1991.
- CIDA which published a report on Environment and Development in Bangladesh in 1990.
- UNDP supported the development of the National Environmental Management Action Plan in 1991. UNDP is also the representative in Bangladesh of UNEP and the Global Environmental Facility (GEF).

In addition, as mentioned earlier, a number of donors such as Asian Development Bank and UNDP have supported projects to develop strengthen the Department and Ministry of Environment. A number of bilateral donors are also supporting environmental activities of NGOs.

The donors have also framed a Local Consultative Group which meets in Dhaka periodically, coordinated by UNDP, to share information on different donors activities on environmental issues.

Conclusions

As will be apparent from the far from complete list of activities in different environment sectors, environment has become an important and integral part of the activities of the involved actors. Some suggestions are made for the different actors to consolidate and strengthen their activities in the future.

Government: The Government needs to implement the Environmental Policy and Action Plan as soon as possible and particularly, strengthen the requirements and capabilities for carrying out Environmental Impact Assessments (EIAs) for major projects.

Academia: The universities and other educational institutions need to develop curricula and training on environmental issues, particularly, regarding training for conducting Environmental Impact Assessments of projects.

NGOs: The research and media oriented NGOs need to establish and disseminate better information and publications relating to environmental issues, while the development oriented NGOs should incorporate sound environmental aspects in their programmes.

Donors: The donors need to incorporate environmental issues into their main development funding programmes, as well as to fund specifically, with additional funding for environmental projects.

CHAPTER FIVE

ENVIRONMENTAL EDUCATION AND AWARENESS

A. M. Sharafuddin and A. Atiq Rahman

The environment has become a focus of world wide attention today. Environmental problems to a large extent differ from country to country. But many of the issues have by now assumed common and global proportions. In most countries, environment related problems have assumed such a pronounced form that even the man on the street has become conscious of the adverse changes in the environment and of the prospect of worse developments that may be looming in the foreseeable future. Among such changes are the scarcity of pure drinking water, depletion in the stock of forests and fire wood, damage to fish stock caused by mounting pollution in the water bodies, degradation of farm lands resulting from indiscriminate use of chemical fertilizers and pesticides, and rapid growth of slums in the urban areas.

The environmental concerns were first widely expressed in the advanced industrialized countries as recently as in the early sixties of this century. But these were not limited to such countries for very long because the baneful effects of environmental change also began to affect most of the developing countries such as Bangladesh. While in the industrial countries chemical pollution of air and water began to create, for example, such phenomena as acid rain, in other countries like Bangladesh and Nepal severe deforestation and consequent floods started to cause great concern. Some of these changes are affecting our immediate lives, but others, often of much larger proportion, are looming large on the horizon with their severe destructive potential.

National Awareness and Early Measures

Bangladesh, with its very high population density, backwardness in technological development, and proneness to environmental hazards owing to its peculiar geographical situation, became aware of the problems of the environment fairly early among the developing countries. The realization that "the natural environment is a finite resource and does not have the capacity to absorb and cushion all the adverse impacts imposed on it"[1] dawned on the national policy makers as well as the general population almost immediately after the country gained independence early in the seventies.

Bangladesh, one of the most populous countries of the world (population density is currently more than 800 per km^2), has several natural assets. It is located in one of the most fertile deltaic regions of the world. The climate is favourable to the growth of crops throughout the whole year. The country has more freshwater resources per capita than most countries of the world. Its water bodies harbour a large variety of fishes, prawn and other flora and fauna of considerable economic value. However, the state of technological under-development coupled with rapid growth of population (current growth rate is about 2.1 per cent per annum) is resulting in rapid depletion and degradation of the natural resources of the country.

Moreover, in the recent years, environmental degradation in the region has increased the intensity of major natural calamities such as floods and cyclones and Bangladesh has had a more than usual share of these. It is apprehended that in the near future the country will be experiencing more of these natural hazards, e.g., frequent floods, increased soil erosion, unusual droughts, and inundation of coastal areas as a consequence of global warming caused by the Greenhouse Effect.

As a result of the concern for the environment, some administrative measures were taken by the Government in the early years of independence. Among these steps were the passage of the Water Pollution Control Act of 1973 and, later, the Environment Pollution Control Ordinance of 1977. As a sequel, an Environment Pollution Control Board was set up and an Environment Pollution Control Project was initiated in 1977. A Department of Environment Pollution Control was created in 1982 which was renamed as the Department of Environment and placed under the newly formed Ministry of Environment and Forest in 1989.

Over the eighties, the awareness of the environmental problems grew in the country at all levels and in all sectors. Among the areas in the environmental field which have been identified as development priorities by the Government of Bangladesh are the following:

- Development of environmental infrastructures;
- Development of human resources through training, education and research; and
- Creation of mass public awareness for protection and enhancement of environmental quality.

Bangladesh observed 1990 as the "Year of the Environment" and the decade of 1991-99 has been declared as the "Decade of the Environment". The Government has recently banned the export of frog legs as well as of all kinds of birds and animals as a step towards the preservation of the natural environment and ecological balance in the country. A National Conservation Strategy and a National Environment Policy have been formulated and are in the process of being adopted. These are some of the indicators of the positive interest of the Government and the people in environmental protection and development.

Implications for Education

While the average man on the street, or on the farm, becomes quickly aware of the adverse changes in the environment which affect his life, he may not always know or understand the factors which cause these changes. Often people without proper education even think that such changes are after all inevitable, or even acts of God, beyond human control, and hence lack the will for any remedial action. But scientists, who investigate such phenomena, tell us that most of these changes are caused, directly or indirectly, by the actions of man and hence can be controlled through proper planning.

Since the days of the Industrial Revolution, man has increased his productive capacities manifold. Over the last two centuries, a great flowering of scientific knowledge has taken place, many new technologies have been generated, which, in their turn, have produced an abundance of consumption goods. New energy sources have been tapped, new materials created, many

diseases conquered and a large share of humanity has been able to taste the 'good life.'

As man has increased his mastery over nature, his numbers have been increasing fast. His needs have also been increasing at a correspondingly accelerated rate—resulting in even greater demands on the limited resources of the earth.

The developments of the past two centuries have, unfortunately, not been all in the right direction. Reckless search for the 'good life' has often put on nature many scars of unkind human intervention. The finely interwoven balance of nature has started to be disturbed here and there. Rich and poor nations have been exploiting nature with equal lack of concern for the future—the rich countries using more of the resources than the poorer ones. Thus the rate of use of physical and biological resources of the earth has, in many cases, gone beyond the limits of natural regeneration. Destructive use of such resources has started to impose limits on the sustenance of the very process of development.

Over a large part of human history, either consciously or unconsciously, man has been modifying the natural environment through his actions. Some of these actions influence the environment in a positive manner, others in a negative manner. These influences result from group actions as well as individual actions. Some of the effects are planned or anticipated while others are not. Often men act in a manner which produces a negative effect on the environment because they are not aware of the consequences of such action.

In order to create this awareness of the importance of conservation of the natural environment, action is needed at various levels and in various modes. Among the different levels are the national policy makers, community leaders, professionals of various disciplines; teachers, students and youth groups; women, cooperators, religious leaders and other special groups; workers, peasants and the lay public. In terms of mode of dissemination, the awareness programmes may be a part of the formal educational curriculum; these may also be part of informal programmes and delivered through other communication media. Needless to say, the treatment of the message of conservation should, in all cases, be tailored to the various levels and modes of presentation.

In the advanced countries, which have a high level of educational development, environmental issues are interwoven into the educational curriculum. In Bangladesh, educational coverage beyond the primary school level is

relatively low. However, issues relating to the environment have been incorporated in the curriculum of both the primary and secondary stages.

Coverage in Formal Education

In Bangladesh, immediately after independence, the government set up a Bangladesh Education Commission in 1972 under the chairmanship of a distinguished scientist named Dr. M. Qudrat-i-Khuda to frame a comprehensive education policy suited to the needs of the new nation. The Commission submitted its Report in 1974.[2] In the light of this report, a National Curriculum and Textbook Committee was set up in 1975 and the Committee completed the framing of new curricula and syllabuses for various stages of school education by 1978. New textbooks were written according to the new syllabuses and these began to be introduced, in stages, in 1978. In this syllabus, in place of the earlier science and social studies, an integrated subject called Environmental Education was introduced in the Primary (grade 1-5) and Junior Secondary (grades 6-8) stages. In the syllabus of Environmental Education for grade 3, there are such topics as "the causes and effects of degradation of the environment," "the need for and methods of conservation of the environment" and wastage and pollution of water—their prevention and the conservation of water resources." Such themes are continued till the end of the secondary stage.

The main principles according to which the syllabus of Environmental Education for the primary stage was prepared were the following[3]:

- the pupils would be able to observe and know their immediate environment and develop a scientific attitude in solving their every day problems.
- the study of separate subjects like biology, physics, chemistry, geography, geology, history, social studies, etc, do not help young pupils to learn about the totality of the environment; hence an integrated subject would be more useful;
- knowledge about proper use of the resources of the environment and of their conservation is essential for the maintenance of human life and of civilization.

The subject matter of Environmental Education at the Primary stage starts in grade 1 but in grades 1 and 2 it is taught orally without any prescribed text book (a teachers' guide is, however, provided by the National Curriculum and Textbook Board to all schools). The subject matter begins with the family environment; moves through such immediate concerns of the children as family food, clothes, shelter, domestic animals and birds to the school and village environment; various living and non-living objects in the local environment; the need for a neat and clean environment; the relationship of health and hygiene with the environment.

Starting from grade 3 the subject is treated under two heads, viz, Environmental Studies (Science) and Environmental Studies (Society). The subject matter included in Environmental Studies (Science) in grades 3-5 covers such elements as rudimentary knowledge of the earth, the solar system and the universe; the inanimate and the animate worlds; man and his environment; preservation of the environment; food, nutrition and population; agriculture and agricultural development in Bangladesh; various natural resources of Bangladesh.

The subject matter of Environmental Studies (Society) covers such elements as the social environment; region and regional environment; ways of life of people in different environments; environment and living conditions; change of environment and people's lives. Similar topics are continued in the secondary stage of schools as well.

Recently, the National Curriculum and Textbook Board has taken steps to improve the presentation of the Environmental Education text books, along with other subjects of the primary stage (grades 1-5) based on the principle of Essential Learning Continua. The cycle is expected to be completed for the primary stage by 1996. Steps are afoot to introduce such improvements in the secondary level textbooks also shortly.

One of the problems in environmental education is the great dearth of supplementary reading materials for the pupils as well as of appropriate AV aids to teaching. The present school curriculum advocates an activity-based method of teaching; but such a method presupposes sufficient number of teachers, basic educational facilities in the form of suitable classrooms and work space, educational equipment, visual materials, etc. Unfortunately, most educational institutions in Bangladesh run under severely constrained conditions in these respects. There is also a great need for teacher training,

both pre-service and in-service, to give the teacher proper knowledge and orientation of environmental education. A suitable restructuring or modification of the teacher training curriculum of the Primary Training Institutes (PTIs), for the primary teachers, and of the Teachers' Training Colleges (TTCs), for the secondary teachers, would be helpful.

Higher Education Research

At the level of higher education, which is provided in ten universities and about 800 colleges in the country, ecology is a component of a paper under such subjects as botany and zoology in the degree pass course (2-year duration after higher secondary grades 11-12) and a full paper in botany in the Honours course (3-year duration after grades 11-12). Practically all the major universities of the country have included ecological considerations in the Honours courses in such subjects as botany, zoology and geography. At the post-graduate level, there is a compulsory paper on Ecology in post-graduate classes in botany and zoology. In the University of Dhaka, at the M.Sc. level there are also courses on Environmental Management and Perception and Resources Management and Environment in the Department of Geography. Similar environment related courses are also offered in the Bangladesh Agricultural University and the Bangladesh University of Engineering and Technology. However, the facilities for research in the universities in Bangladesh are extremely limited.

A number of research organizations in the country have in recent years developed extensive research capabilities in the field of environment. Among these are:

- Bangladesh Agricultural Research Council (BARC) which coordinates a national agricultural research network in Bangladesh including such agencies as the Bangladesh Agricultural Research Institute (BARI), Bangladesh Rice Research Institute (BRRI), Bangladesh Jute Research Institute (BJRI), Bangladesh Agricultural University (BAU), Department of Fisheries, etc.
- Bangladesh Institute for Development Studies (BIDS) has a strong team of economists and social scientists and a solid capacity for macro-economic research in various areas related to resources management and ecological studies.

- Institute of Forestry in Chittagong which is the sole institution in the country providing university level education in forestry.
- Bangladesh Council of Scientific and Industrial Research has extensive capacity for research on the industrial aspects of the environment but it is not being properly utilized.
- Space Research and Remote Sensing Organization (SPARRSO) has been involved in studies related to agriculture, fisheries, forestry, oceanography, water resources, weather forecasting and cyclone warning, etc. using remote sensing technology.
- A number of private research agencies such as the Bangladesh Centre for Advanced Studies (BCAS) and Centre for Development Research have in recent years initiated some research activities in the field of environment and their efforts are likely to gather momentum in the coming years.

Non-formal Education

In the non-formal sector, environmental education programmes are regularly aired by Radio Bangladesh and Bangladesh Television, which have nation wide coverage. The newspapers have, of late, been giving wide coverage to environmental issues. These relate to natural calamities such as floods and cyclones, land erosion, water pollution, deforestation, industrial effluent, destruction of wild life, and the like.

The NGOs are encouraged to undertake programmes on environmental improvement in various ways. Such NGOs as the 'Society for the Conservation of Nature and Environment' and 'Monsoon Region Environment Society' have been active in sponsoring environmental awareness programmes among the people. The World Environment Day is observed on 5 June every year by the Governmental agencies as well as by many NGOs operating in the environmental field. Discussion meetings, etc are organized on the occasion.

Among its many recommendations relating to the improvement of the education system, the Bangladesh Education Commission of 1974 proposed that every school should have a science club for nature study and exploration of the environment. Already there are about 400 science clubs in the

country; some of these are based on the schools, some are based on the locality. These clubs have their own programmes for creating environmental awareness and nature conservation.

Under the auspices of the Bangladesh National Commission for Unesco, a Man and Biosphere (M & B) Committee has been set up in the country under the chairmanship of a member of the Planning Commission. Various other governmental ministries and agencies have their own projects relating to environmental awareness.

Role of the NGOs

The Non-Governmental Organizations (NGOs) in Bangladesh have been taking an increasing role in creating environmental awareness among the people and organizing various appropriate training programmes for the concerned groups. These organizations have in recent years gone through a transition in their approach in that their focus has gradually shifted from basic relief and rehabilitation to various levels of sophistication in development activities.

People's Traditional Wisdom

Even though the large majority of the people in the country have had no chance to go through a process of formal education, they have been using their own devices to cope with environmental problems. In various areas of the country, local methods of farming, fishing, health care and other technologies based on age long experience have been in practice among the people. Such traditional wisdom and technologies, often based on environmentally sound practices, may be pressed into service to some advantage in coping with the environmental problems.

Agricultural practices in Bangladesh have for long depended or proceeded on the basis of versified words of wisdom called *Khonar Bachan* (Sayings of Khona, a mythological wise lady). According to some, Khona is a historical person—wife of astronomer *Mihira*, court scholar of *Vikramaditya* (AD 380-413) and herself an accomplished mathematician and astronomer. Others consider Khona to be an imaginary person, her sayings symbolizing folk wisdom based on centuries of farming practices.[4]

One of Khona's sayings goes like this: *Magher mati heerer kati / Falguner mati shona; Choiteyr mati jemon temon / Baishakher mati mona.* It means, the best time to start preparation of soil for cultivation is the month of *Magha* (mid-January to mid-February); the month of *Falguna* (mid-February to mid-March) is also quite good; *Chaitra* (mid-March to mid-April) is so so, but the soil is no longer suitable in *Baishakh* (mid-April to Mid-May).

There are many such sayings on the effect of weather on crops. For example, *Diney rode, ratey jol / Tatey barey dhaner bol.* It means, if there is sunshine during the day and rain at night, it would give a good rice harvest.

Some of Khona's sayings relate to the prediction of storms, e.g., *Bianey auli bauli dupurey bow / Diney boley Khoraneyr ghar jow.* It means, if there is irregular wind in the morning and steady flow at noon, you can expect a storm.

Other types of folk sayings and folk remedies relate to health care, protection of crops and conservation of natural resources. For example, local plants like *Neem (Azadirachta indica)* and *Bishkatali (Polygonum sp.)* are used in many areas for protecting food grains from pests during storage. By convention, rural people do not eat catfish during the month of *Chaitra* (mid-March to mid-April). This is the period when the water bodies in rural Bangladesh are relatively dry, hence the level of pollution is high and the preservation of such fish for the next season require that their stock not be exhausted during the dry season.

It may be useful to compile examples of such folk wisdom and make appropriate use of them to educate the common people about conservation of nature and the environment.

Conclusion

It is clear that environmental awareness has to be developed through both formal and non-formal channels of education. There is also a great need to use the indigenous knowledge of the people in coping with environmental hazards.

In a country like Bangladesh, where only about 35 per cent of the adult population are literate, and only 75 per cent of the primary age group and 20 per cent of the secondary age group are able to attend school, the need for non-formal education assumes particular significance. Such non-formal education can be arranged through science clubs and other children's and youth

organizations and various social welfare bodies. Every year, during the first week of July, annual campaigns are organized as a routine for tree plantation and other conservation issues. There is obviously scope for broadening the coverage of these campaigns and making these more action-oriented.

Conservation education is obviously not isolated from general education. It is hard to imagine an illiterate population developing a broad awareness of social issues and becoming keenly active for conservation. A strong programme of conservation education calls for a strong and universal programme of general education.

Such general education at a formal level will mainly reach the children and young people. In order to reach the adult population, most of whom do not have much of a background of formal education, various print and non-print media (such as radio and TV) can be used.

The following recommendations are made for improvement of the present status of environmental awareness and education in Bangladesh:

- Steps should be taken for updating and improving the content and methods of teaching environmental education in general science and other courses for the secondary level as early as possible.
- There should be adequate coverage of environmental education in the teacher training programmes for primary and secondary school teachers —both in-service and pre-service.
- Arrangement should be made for the provision of audio-visual materials on environmental education for both formal and informal education.
- Courses on environmental education should be strengthened and updated in all the universities and institutions of higher education in the country. Appropriate funds and other facilities should be provided for conducting research on environmental issues.
- Studies ar needed on traditional technologies used by people in coping with environmental problems and the more appropriate ones should be widely disseminated.
- The press should give more coverage to environmental issues. Since a large population in Bangladesh is illiterate, there should be regular weekly or fortnightly programmes on radio sand TV on issues relating to the environment.

- The Department of Mass Education should arrange film shows on environment and nature conservation in both rural and urban areas.
- The NGOs should be provided with assistance and support in their efforts at creating awareness about the environment and its protection.

If the issues of development and conservation are important for Bangladesh and the world today, these would be more so in the days to come. Bangladesh, in particular, presents a unique case with a very high population density, a rather high population growth rate, and limited natural resources. Hence the issues of development and conservation take on an added significance for Bangladesh. History and circumstances do not leave the country much scope to waste time. Only a large scale programme of environmental awareness and education can lead to mass action for protection of the environment consistent with the urgent needs of national development.

Notes

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[1] *Towards Sustainable Development: The National Conservation Strategy of Bangladesh*. Dhaka: The Ministry of Environment and Forest, Government of Bangladesh, International Union for Conservation of Nature Resources, July 1991.

[2] *Bangladesh Education Commission Report*. Dhaka, 1974.

[3] National Curriculum and Text Book Committee, *Report, Part I (Primary Stage), Part II (Secondary Stage)*. Dhaka: 1977.

[4] Nawaz, A. *Khonar Bachan. Krishi O Banglai Samskriti* (Khona's Sayings: Agriculture and Bengali Culture). Dhaka: Bangladesh Agricultural Research Council.

CHAPTER SIX

SEA LEVEL RISE AND BANGLADESH

Saleemul Huq, Syed Iqbal Ali
A. Atiq Rahman

Abstract

Bangladesh has an area of only 144,000 square km and 115 million people. The per capita GNP was US$170 in 1990, but for over 70% of the population the per capita GNP is below US$100. The country is mostly a very low-lying river delta with three major river systems flowing through it—the Ganges, Brahmaputra and the Meghna. A recent study by the Bangladesh Centre for Advanced Studies (BCAS) has identified the following major impacts of a one-meter sea level rise (SLR).

Population Displacement: Over 11% of the population (more than 13 million people) will be displaced by only the coastal effects of a one-meter SLR.

Area Inundation: More than 17.5% of the total land area (over 25,000 sq km) will be totally inundated.

Existing Infrastructure Affected: Some 85 cities and towns, one major port (Mongla), over 800 km of roads, 28 km of railways, 4,200 km of coastal embankments, and over 7,500 sq km of poldered areas will be invaded.

Ecosystem Destruction: Sunderbans, the world's largest mangrove forest (5,770 sq km), is threatened with extinction by sea level rise. This contains amongst the largest biodiversity of mangrove forest in the world. It is also the home of the Royal Bengal Tiger, which will vanish.

Coastal Islands Threatened: Many coastal islands, covering an area of 3,500 sq km, will be inundated. These islands are already vulnerable to cyclones, which will increase due to global warming.

Agricultural Production Loss: Over 3 million acres of breadbasket land consisting of 21% of the country's monsoon rice land, producing 16% of the country's rice, will be lost due to inundation.

Coastal Shrimp Production: Shrimp production earns millions of dollars in exports and depends on the mangrove forest. A one-meter SLR will destroy this aquatic resource.

Abatement Costs: The study undertook an assessment of the abatement costs to give the minimum protection against a one-meter SLR. Bangladesh will have to embank 715 km of coastal island perimeters, 370 km of coast, and 7,600 km of river banks. There already exists 4,800 km of embankments and 4,000 km of new embankment would be required. This will cost Bangladesh over US$billion at current rates.

The study also reported that global temperature increase may cause greater melting of Himalayan ice with an increasing water flow. Increasing SLR will decrease the gradient of flow and thus will spread the excess water inland causing more flooding. Further, Bangladesh is frequently devastated by natural disasters including cyclones and flooding. Global warming and the consequent SLR will exacerbate these disasters.

Introduction

The possibility of a rise in mean sea level due to global warming (or the Greenhouse Effect) has caused considerable interest amongst the international scientific community for some time and more recently amongst scientists, government officials, and the general public in Bangladesh. The interest in sea level rise as a consequence of the Greenhouse Effect has coincided with a major concern about environmental issues in general in Bangladesh which was triggered by the devastating floods of 1988 and cyclones of 1989 and 1991.

Bangladesh being a very densely populated (approximately 115 million people) low lying area of only about 144,000 square kilometres, on the delta of three major rivers of the world, namely, the Ganges, the Brahmaputra, and the Meghna, is one of the countries most vulnerable to the effects of global climate change particularly sea level rise. Its per capita GNP was

US$170 in 1990, but for over 70% of the population it is less than $100 (Hossain, *et al.*, 1992).

The possible consequences of a rise in sea level on Bangladesh was first documented by Broadus *et al.*, (1986) who took the 1 and 3 m contour lines along the coast of Bangladesh to show that 12 and 30% respectively of the country's land area would be inundated by a sea level rise of those magnitudes. This approach was based on maps whose data had been collected several decades ago including tidal maps and contour lines that were not very accurate. However, it was a reasonable approximation and succeeded in raising the alarm.

This study has attempted to calculate the effects of a 1.0m sea level rise based upon more updated information and data including topographical maps, tidal tables, satellite and aerial photos and hydrographic maps. Thematic maps were then used to estimate the effect of a 1.0m sea level rise on agriculture, population, and infrastructure and some estimates of such effects were also made.

Available Maps and Data

Topographical Maps

Topographical maps are published by the Survey of Bangladesh on 1:50,000 scale. They show planimetric details with contours generally at 50ft intervals. Topographical maps at larger scale with contours at 1ft. intervals have been prepared for project areas; particularly for the water development projects. These are called Project Maps and are surveyed and prepared by the Survey of Bangladesh for various agencies.

The 1:50,000 series maps were prepared during the British colonial period (before 1947) by the then Survey of India and were subsequently revised and corrected by the Survey of Bangladesh by using aerial photographs of different dates.

Large scale contour maps with 5 feet intervals are also available but are difficult to obtain.

As Bangladesh lies on an active delta and is subject to annual flooding and deposition of silt and sand the land levels and river courses are constantly undergoing changes which have taken place in the coastal area over the last hundred years.

Hydrographic Survey Maps

The Inland Water Transport Authority (IWTA) conducts yearly hydrographic surveys of the Bangladesh coastal waters and publishes maps and charts. These maps are a very good source of data on the bottom topography of the offshore waters of the Bangladesh coast. They are found in different convenient scales for various years.

Aerial Photographs

Aerial photographic coverage of the whole of Bangladesh are available for several years (1952, 1975, 1948) on 1:30,000 and 1:50,000 scales.

These photos are useful for the assessment of SLR impact studies But, these are difficult to procure as they are regarded as classified.

Satellite Images

LANDSAT images of Bangladesh are available in different bands for different dates from 1971 to present. Thematic mapper in LANDSAT system gives images with better resolution. NOAA images are also available for Bangladesh but due to their coarse resolution these images are not very suitable for use in SLR impact assessment.

SPOT images would be very useful for SLR impact studies as their resolutions are fine (10 meters in panchromatic and 20 meters in colour modes). Scales of the SPOT images are also convenient for SLR studies, ranging from 1:25,000. SPOT images also allow stereoscopic interpretation. SPOT data are costly and they have to be procured from outside the country as Bangladesh does not have ground station to receive SPOT images.

Tide Table and Maps

IWTA undertakes hydrographic surveys and tidal recording of the coastal area and in major inland waterways, and publishes maps. It has a large number of tide recording stations and tide data available. It also publishes cotidal range maps and tide table every year. These data are very useful for SLR studies.

Thematic Maps

Thematic maps on Bangladesh mostly on small scale are also available from various sources. These include among others the following themes: administrative units; location of cities, ports, industries, forests, tourist spots, population distribution and densities, road, railways, waterways, embankment, landuse, distribution of agricultural crops, etc. These thematic maps are very useful for SLR impact assessment for Bangladesh as many of them furnish quantitative mapped data.

In addition to these mapped data various socio-economic data are available on lowest administrative unit basis (union level) in the publications of the Bangladesh Bureau of Statistics. Maps can be drawn from these data for use in a SLR impact study.

Historic Mapped Data Base

Maps of major floods are available for different years in published form, other maps showing flood frequency and floodibility are also available. NOAA images taken during the flood periods in different years are available but due to cloud coverage and coarse resolution these images have limitations for use in the SLR studies.

Most of the available flood maps were done through rapid reconnaissance surveys, land surveys and from satellite imageries.

Coastline Change

Maps of coastline are available since Rennel's time (1776). Maps of the coastline published prior to Rennel are less reliable as they were not done by proper surveys. Modern maps of the coastline prepared by IWTA, BWDB, Survey of Bangladesh, and SPARRSO are good and reliable. These maps can be used to show the changes that have taken place due to erosion and deposition.

IWTA maps showing coastlines are available in small scale (e.g. 1:5,00,000). BWDB project maps which are on large scale (1" to 8 miles) are available for portions of the coast where there are coastal embankment projects. Coastline shown in topographic maps published by Survey of Bangladesh in 1:50,000 scale and maps prepared by SPARRSO from satellite imagery are reliable.

Methodology

Delineation of Area Inundated Due to SLR

For the purpose of delineation of the area that would be inundated due to 1.0m rise of sea level, it was assumed that the following parameters would be relevant:

1. Contour (Figure 1) showing the vertical height above sea level.
2. Cotidal range (Figure 2) showing the range of tidal influence which may migrate inland due to increase in sea level.
3. Flood inundation level (Figure 3) showing the most flood prone areas.
4. Physiography (Figure 4) showing the low lying areas, both coastal as well as inland.
5. Surface drainage (Figure 5) showing the likely path for ingress and outflow of water.

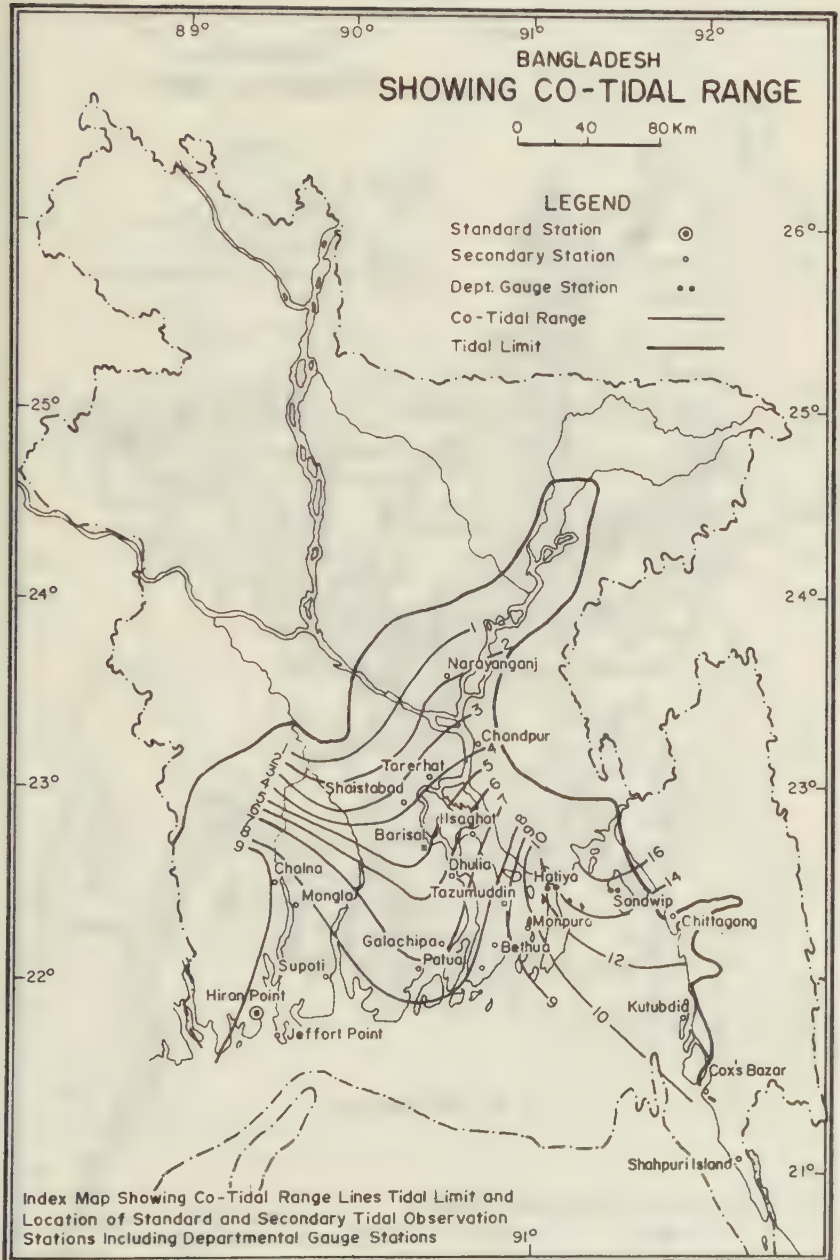
Maps of Bangladesh showing all the above parameters were collected and were brought to the same scale. They were then drawn clearly and transferred on to transparent sheets. Cotidal range maps were superimposed on the contour map and the location and orientation of the cotidal range line with respect to the critical contour viz. 1.0m was studied to assess the magnitude of tidal fluctuation that would occur along the critical contours. Then looking at the spacing of the contour lines next to the critical contour, the slope of the land away from the critical contour was evaluated. In the next step the inundation depth map, physiographic map and surface drainage map were further superimposed to find out the location of major deeply inundated areas, basins, rivers, and channels along the critical contours. The line showing inundation due to 1.0m SLR was then drawn carefully by applying judgement and the situation of the cotidal range lines, inundation depth, physiography and drainage in order to decide the area which would be likely to be inundated by 1m SLR.

The line thus obtained shows somewhat different levels of inundation than that shown by Broadus *et al.*, (1986).

A map was drawn showing clearly the inundation levels at 1m sea level rise and was then used as the base map to proceed with the assessment of the impact of SLR (Figure 6).

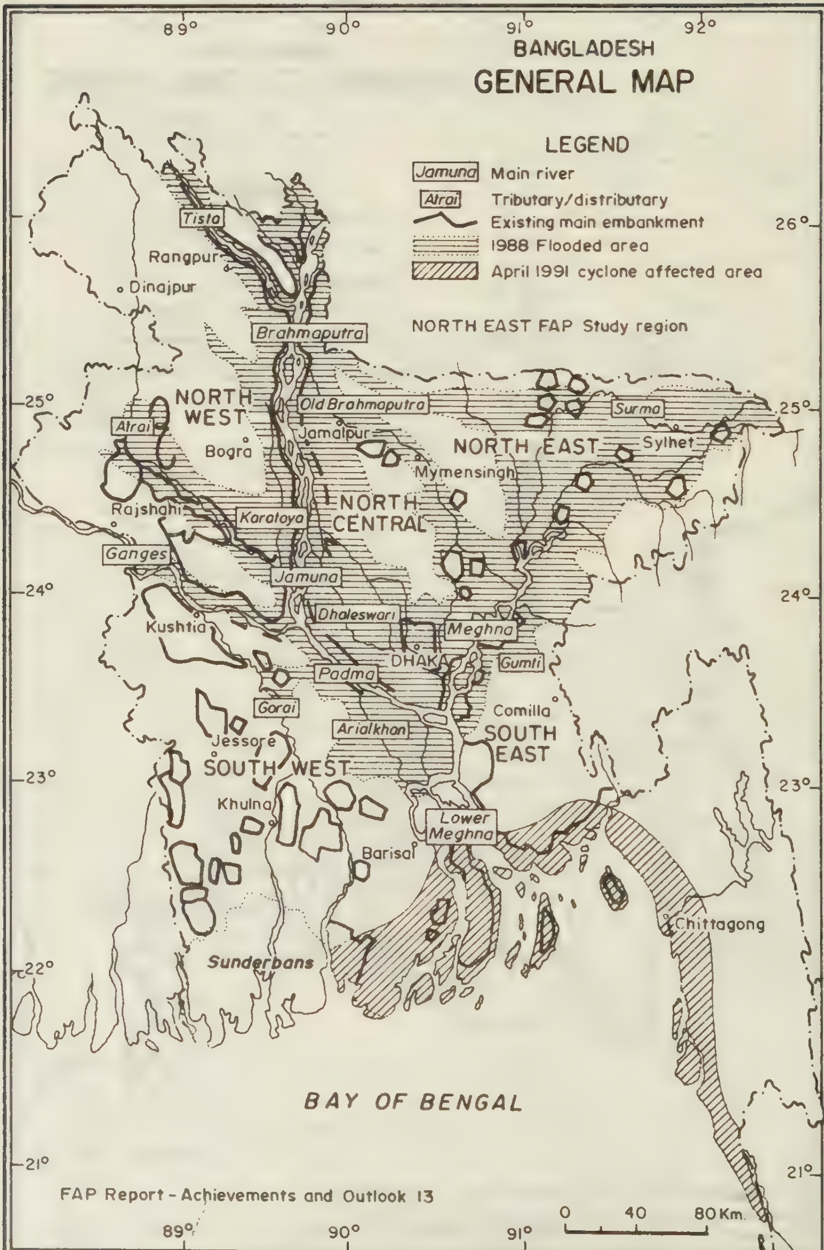
Figure 1

Figure 2



Source: IWTA, Bangladesh Tide Tables, 1986

Figure 3



BANGLADESH
GENERAL MAP
LEGEND
Jamuna Main river
Atrai Tributary/distributary
Existing main embankment
1988 Flooded area
April 1991 cyclone affected area
NORTH EAST FAP Study region
89°
90°
91°
92°
26°
25°
24°
23°
22°
21°
Tista
Rangpur
Dinajpur
Brahmaputra
NORTH WEST
Old Brahmaputra
Surma
Atrai
Jamalpur
Sylhet
Bogra
NORTH EAST
Mymensingh
Rajshahi
Karatoya
NORTH CENTRAL
Ganges
Jamuna
Dhaleswari
Kushtia
Meghna
DHAKA
Gumti
Padma
Gorai
Comilla
Arialkhan
SOUTH EAST
Jessore
SOUTH WEST
Khulna
Lower Meghna
Barisal
Chittagong
Sunderbans
BAY OF BENGAL
FAP Report - Achievements and Outlook 13
0 40 80 Km.

Figure 4

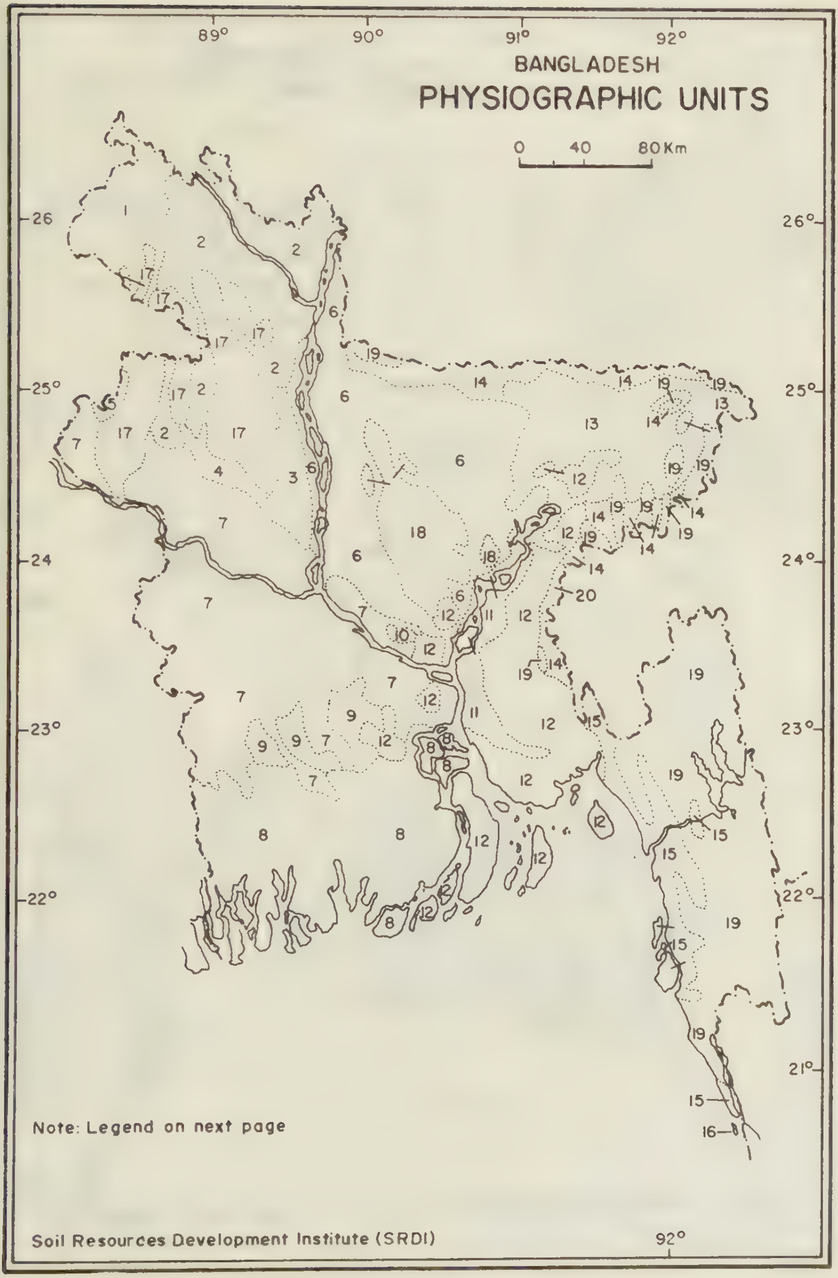

BANGLADESH
PHYSIOGRAPHIC UNITS
0 40 80Km
89°
90°
91°
92°
26
26°
25°
24
24°
23°
22°
21°
Note: Legend on next page
Soil Resources Development Institute (SRDI)

Figure 5

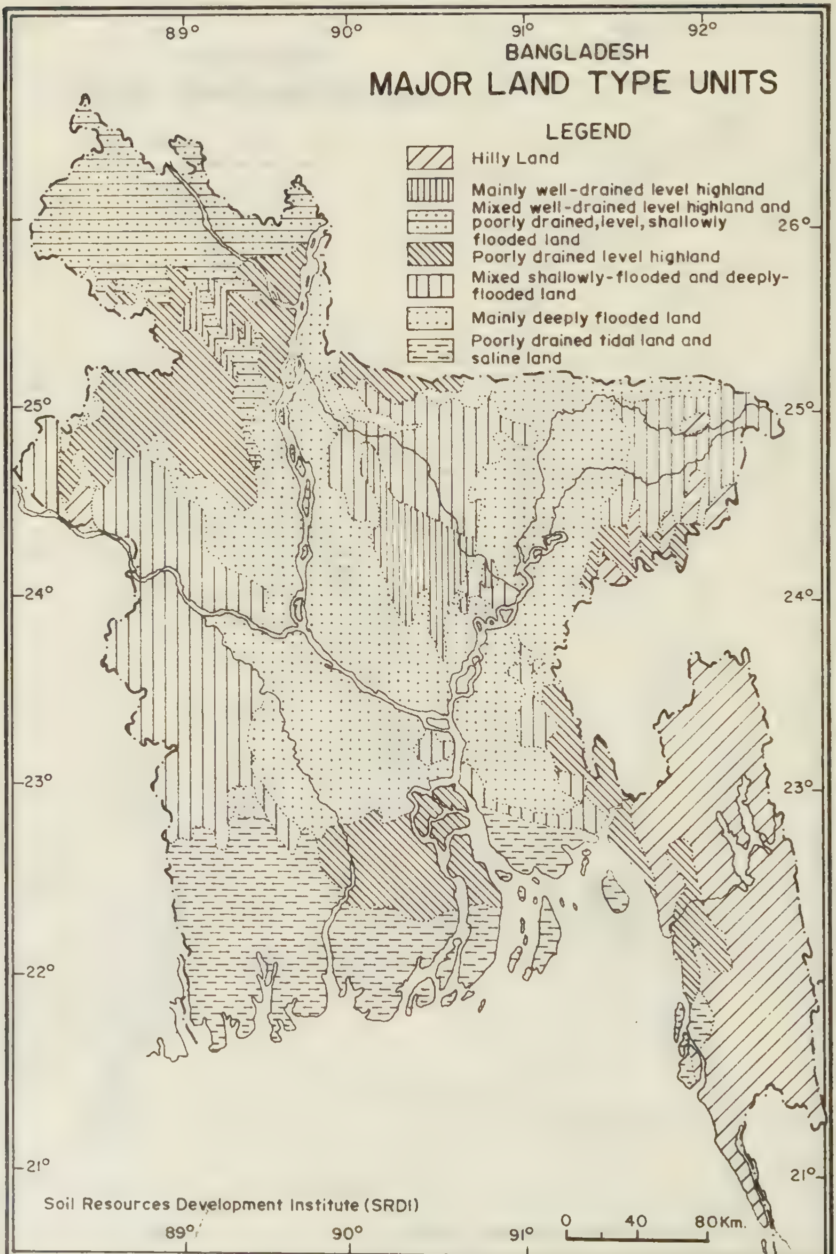
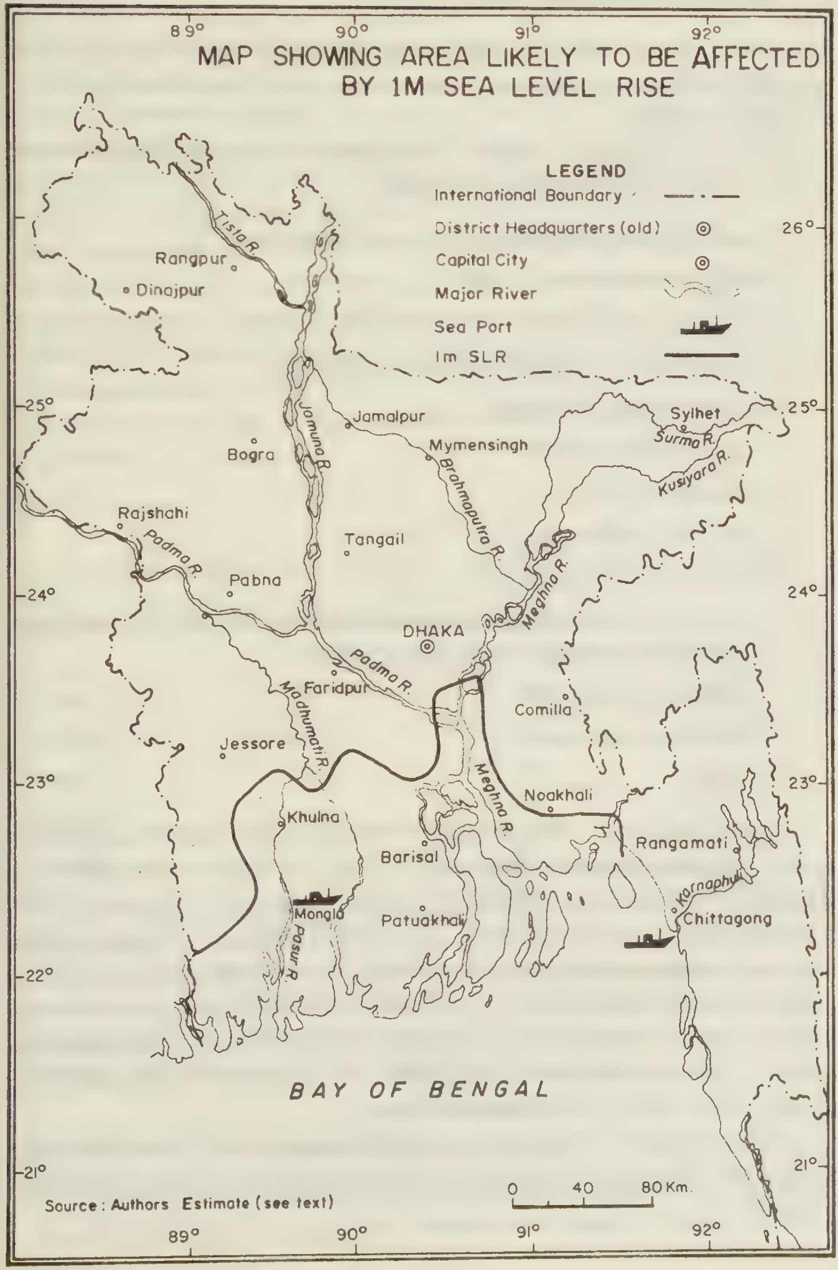

BANGLADESH
MAJOR LAND TYPE UNITS
LEGEND
Hilly Land
Mainly well-drained level highland
Mixed well-drained level highland and poorly drained, level, shallowly flooded land
Poorly drained level highland
Mixed shallowly-flooded and deeply-flooded land
Mainly deeply flooded land
Poorly drained tidal land and saline land
89°
90°
91°
92°
26°
25°
24°
23°
22°
21°
0
40
80Km.
Soil Resources Development Institute (SRDI)

Figure 6


MAP SHOWING AREA LIKELY TO BE AFFECTED BY 1M SEA LEVEL RISE
LEGEND
International Boundary
District Headquarters (old)
Capital City
Major River
Sea Port
Im SLR
89°
90°
91°
92°
26°
25°
24°
23°
22°
21°
Rangpur
Dinajpur
Tista R.
Jamalpur
Mymensingh
Sylhet
Surma R.
Kusiyara R.
Bogra
Jamuna R.
Brahmaputra R.
Rajshahi
Padma R.
Tangail
Pabna
Meghna R.
DHAKA
Faridpur
Madhumati R.
Comilla
Jessore
Noakhali
Khulna
Barisal
Rangamati
Mongla
Patuakhali
Karnaphuli
Chittagong
Pasur R.
BAY OF BENGAL
0
40
80 Km.
Source : Authors Estimate (see text)

National assessment of impact of SLR

The map of Bangladesh showing extent of inundation due to 1m SLR prepared as described above served as the base map and was transferred on to transparent sheets.

The following thematic maps of Bangladesh relevant for the assessment of impact due to SLR were then collected:

1. Administrative maps up to Thana and Union level
2. Population distribution map
3. Location map of urban area, habitat, cities, ports
4. Location map of forest including mangroves
5. Location map of industries
6. Land utilisation maps
7. Map showing railways
8. Distribution of major crops
9. Maps of coastal aquaculture
10. Location maps showing present and planned embankments and flood control, and drainage and irrigation projects
11. Location of industries
12. Inland waterways/ports
13. Roads

All the above maps were brought to the scale of the base map prepared earlier showing inundation levels due to 1m SLR and were transferred to transparent sheets. Overlaying these thematic maps on the base maps, impacts of SLR at 1m on agriculture, industries, habitation, communication, etc., were assessed by direct measurement from the map. For example, by counting the number of dots located within 1m SLR level, potential impacts on population and crop land loss were estimated and by measuring the length of embankments, road, and railway on the map by a rotameter, impacts on these infrastructures were estimated.

For the purpose of producing an impact assessment on a national scale, small scale maps were used. As a result the values give a gross estimate only.

Results

Population

Table 1 shows that 6 greater districts of Bangladesh would be affected by inundation due to 1m SLR (viz. Barisal, Patuakhali, Khulna, Noakhali, Comilla, and Faridpur) covering an estimated area of 25150 km^2 (about 17.5% of the total area of Bangladesh). The coastal districts in the south-west would be the worst affected, about 80 to 100% of these districts would be under the threat of inundation by 1m SLR. However, in the eastern coastal district of Noakhali 50% area would be under such condition. In the district of Comilla and Faridpur, located in the north of the coastal districts. Thus, due to 1m SLR inundation scenario, about 11% (more than 13 million people) of the total existing population would be under threat of inundation.

Table 1

Districts, Area ,and Population Likely to be Affected by 1m SLR

District	Per cent of area affected	Area affected (Sq. km.)	Afected Population
Barisal	90	6,600	4,500,000
Patuakhali	100	4,100	2,000,000
Khulna	80	9,750	3,000,000
Noakhali	50	2,750	1,500,000
Comilla	15	1,000	500,000
Faridpur	15	1,000	1,500,000
Total		25,200	13,000,000

As a per cent of total area of Bangladesh: 17.5%

As a per cent of total population of Bangladesh: 11%

Source: Calculated by authors (see text)

Infrastructure

The effects on different infrastructures of the country of a 1m SLR are shown in Table 2. This shows that about 800 km of roads, 28 km of

railways, 85 towns, and one port will be inundated. Also likely to be lost will be about 3,500 square km of islands (including a coral island) and over 4,200 km of coastal embankments and 7,500 sq km of poldered areas.

Table 2

Effect of 1m SLR on Infrastructure and Habitats

A. Type of Infrastructure	Affect
Roads	800 km.
Railways	28 km.
Cities and Towns	85
Port	1 (Mongla)
Coastal Embankments	4,187 km.
Coastal Aquaculture	64,000 ha.
Poldered Area	7,640 sq. km.
B. Type of Habitat	
Coastal Island	3,500 sq. km.
Forest Area (including Sundarbans)	5,770 sq. km.
Flooded Area (increase)	5,500 sq. km.

Source: Calculated by authors (see text)

Forests

The forest areas likely to be completely lost are the Sundarbans (5,770 sq km) which is the largest mangrove forest in the world and home for many rare and endangered species of animals and plants, including the Royal Bengal Tiger. The mangrove forest is already under threat due to the increasing upstream salinity intrusion caused by lower dry season flows down the Ganges river since the construction of a Dam by India, at Farakka, to divert water to flush Calcutta port. This increase in salinity has already caused the death by "top dying" of the major tree species of the Sundarbans, namely, the Sundari tree. Any increase in sea level by 1m will lead to the destruction of this unique habitat and its many thousands of species of flora and fauna by their complete inundation.

Agriculture

The effects of a 1.0m SLR on agricultural production are shown in Table 3. This indicates that over 21% of the country's monsoon rice land producing 16% of the total rice or 3 million acres of *Aman* (Monsoon) rice, 250,000 acres of *Aus* (Summer) rice and 34,000 acres of jute will be affected. This area has been a grain surplus area in the past from growing the summer season crops (*Aus*, *Aman* and jute) but it is unlikely to remain so in future as the rise in sea level will prevent the growing of these crops. This will also affect the livelihoods of millions of farmers living in these areas. It is also likely that salt water intrusion will affect the land above the 1.0m contour line and thus the agricultural output will be decreased even more than estimated above. Rice production in Bangladesh is also highly dependent on rainfall and other climatic conditions (Mowla, 1978). The Sundarbans are also an extremely important source of fish and shrimp diversity which would be totally lost due to sea level rise.

Table 3

Effect of a 1m Sea Level Rise on Agriculture (Major Crops)

Crop	Area Affected (acres)	% of total for Bangladesh
Aman (Monsoon) Rice	3,160,000	21%
Aus (Summer) Rice	99,000	12%
Boro (Winter) Rice	252,000	8%
Jute	34,000	2%

Source: Calculated by authors (see text)

Cities

Two major port cities of Chittagong in the south-east and Khulna in the south-west of the country would be very vulnerable to a 1m SLR and would need extensive infrastructure protection or raising of port facilities to cope with the rise in sea level.

Coastal Aquaculture

There is very extensive coastal aquaculture being practised, particularly shrimp growing, in the south-western and south-eastern parts of the country. The shrimp grown is mainly for export and represents a major foreign exchange earning for the country amounting to several hundred million dollars a year. These shrimp farms are likely to be all completely inundated by a 1m SLR. However, it may be possible for them to migrate landwards in response to the rising sea level.

Islands

All the coastal islands (covering 3,500 sq km) including Bhola, Hatia, Swandip, and the ecological important coral island of St. Martins will be totally lost under a 1m SLR. In addition to being inhabited by many thousands of people these islands are important areas of biological diversity of both plant and animal species.

Beaches

The south-eastern stretch of Bangladesh near Cox's Bazar has one of the longest beaches in the world (over 100m long) and is one of the major tourist attractions of the country. Almost the entire length of this beautiful beach would be inundated by a 1.0m SLR.

Other Effects

The rise in sea level will have a number of consequences other than simple inundation of low lying areas. These effects will include the following:

Enhanced Flooding

Bangladesh undergoes annual flooding of greater or lesser extent due to both onrush of snowmelt waters from the Himalayan mountains through the two major rivers, Ganges and Brahmaputra, as well as rainfall in the catchments of the rivers, including the third major river the Meghna. These floods can cause tremendous destruction and loss of life as well as damage to crops and

other infrastructure. They also cause the spread of diarrhoeal disease which is the main health hazard for the people of Bangladesh. Any rise in sea level will enhance such drainage congestion and thus increase the duration of future floods.

Further, SLR also causes flooding in additional areas due to backwater effect which will raise the water levels of rivers upstream (Mahtab 1989).

Salinity Intrusion

The ground water aquifer (50-200m below ground level) in Bangladesh is fairly extensive and widely used for domestic as well as agricultural and industrial water supply. Any rise in sea level will increase the salinity level of the coastal ground water aquifer and make it less useful. Already many parts of the coast, including the major port city of Khulna, are facing problems due to salinity of the ground water aquifer.

Similar salinity increase of the surface water systems will also occur and cause problems, particularly in the south-western region of the Moribund Ganges delta which includes the Sundarban mangrove forests. This area is already facing problems of increased salinity intrusion due to reduced river flows in the Ganges which is causing some important tree species, e.g., Sundari to die from increased salinity.

Storm Surges

Bangladesh regularly undergoes cyclonic storms during the months of April and May originating in the Bay of Bengal and moving northward into Bangladesh causing widespread damage. Sometimes these cyclones are associated with tidal waves which increase their devastation many-fold. Any increase in sea level will make it more likely that future cyclones will be associated with tidal waves causing even greater damage (Flaherty and Khondker, 1987).

Compounding Effect of Subsidence

Areas undergoing subsidence in Bangladesh are the Surma Basin, Chalan *beel*, Dhaka Depression and the Khulna Sundarbans areas. The rate of subsidence varies from 0.6 mm/year to 5.5 mm/year and in Surma Basin it

exceeds 20 mm/year. Morgan and McIntire (1959) have provided evidence of subsidence in the recent deltaic plain along the coastal area. The cause of subsidence is due mainly to the compaction of unconsolidated sediments. The effects of SLR may be further compounded by the subsidence in the coastal areas and the extent of inundation due to 1m SLR would be further increased.

Local Hydrometereological Effect

Any increase in flooding period due to sea level rise may cause local hydrometereological effects which will affect agriculture particularly and should also be considered.

Solutions and Responses

As will be evident from the above the problems for Bangladesh are so acute that there are really no easy solutions. Certainly the country on its own will be incapable of mitigating the effects of sea level rise without assistance from the rest of the world. The options are considered below.

Costs of Coastal Defence, mainly embankments (dykes) to protect the coast from inundation has been calculated by the Dutch delegation at the IPCC-CZM sub-group for the whole world, including Bangladesh, taking the total coastal length of Bangladesh's coast to be 2,000 km at a cost of 200 million US Dollars (Dutch delegation, 1989).

We have measured the actual coastal length including major inland creeks and islands likely be to affected by a 1.0m sea level rise and calculated the costs of building embankments using the actual local rates.

For the calculation of cost of embanking the coastal area the following methodology was used.

Area falling within 1m SLR (excluding the Sundarban area) was considered for this estimation. Following linear measurements were made directly from the map with the help of a rotameter:

a. Length of the coast,

b. Length of the coastlines of the offshore islands,

c. Length of the total riverbank falling within 1m SLR limit with the rivers and the Sundarbans excluded.

Adding the above length the total lengths of the proposed embankment was found to be 8,685 km. From this the length of the existing embankments (4,837 km) was deducted. Thus, the cost of the new embankments was calculated using the standard local rates for embankment construction (Table 4)

Rates of constructing coastal embankment were obtained from the Bangladesh Water Development Board schedule of rates and an average rate of construction of the coastal embankments was computed. The total cost of embankment was then calculated (based on 1989 rates).

Table 4

Estimated Length of Existing and New Coastal Embankments needed and costs for construction.

Embankment Type	Length (Km)
Islands	715
Costa	370
Riverbanks	7,600
Total	8,685
Less existing Embankments	4,837
Total length of new Embankment needed	3,848

Source: Authors' estimate (see text).

Notes: 1. The average cost of building coastal embankments by the Bangladesh Water Development Board is approximately $60,000 per km (for earthwork only; the cost including sluice gates and other structures would be much higher). Thus the cost of building embankments for the length of coast not yet embanked would be approximately US$240 million.

2. The total length of existing embankments (4,837 km) which would be affected by a 1m Sea Level Rise is 4,187 km. The cost for raising the height of these embankments would be approximately US$25,000 per km which works out to a total of approximately US$100 million for strengthening and renovating the total length of existing embankments vulnerable to a 1m Sea Level Rise

3. The cost of drainage structures for the embankments would add several hundred million dollars.

Abatement Costs: The study undertook an assessment of the abatement costs to give the minimum protection against a one-meter SLR. Bangladesh will have to embank 715 km of coastal island perimeters, 370 km of coast and 7,600 km of river banks. There already exist 4,837 km of embankments and 4,000 km of new embankment would be required. This will cost Bangladesh over US$billion at current rates.

These embankments would protect an area of 16,659 km^2 from 1m SLR which means that the cost per km^2 of protected land would be approximately US$50,000. Milliman *et al.*, (1989) have estimated total loss at 13% of GDP by the year 2050.

It should be noted however that the mangrove forests of Sundarbans would not benefit from such physical protection as they would require the continuing interplay of saline and fresh water in order to survive.

The cost estimates also do not take into account the dislocation to the people and change in livelihood systems entailed in building dikes around the land.

Political Considerations

The main political factor to be considered is the necessity to relocate the people and infrastructure likely to be affected by sea level rise (assuming they cannot be protected). As Bangladesh is already one of the most densely populated countries in the world (average population density over 1000/sq km) relocation within Bangladesh will cause enormous problems and will be almost impossible and it will therefore be necessary for the world community to come to the assistance of Bangladesh. This is particularly since Bangladesh's contribution to the creation of the greenhouse effect is minuscule compared to many other countries.

Planned Developments Likely to be Affected

With regard to major development investments within the country which are likely to be affected the major programme currently being planned is a series of flood protection embankments on the major rivers at an ultimate cost of billions of US dollars. As mentioned above any rise in sea level will cause likely increase in both magnitude and duration of floods further upstream and therefore such embankments will be less effective (unless they are built to higher levels which will increase the costs considerably).

There are also a number of coastal developments including embankments for agriculture, ports and other cities which are likely to be affected by sea level rise but the government has not yet taken such eventualities into consideration.

The Government of Bangladesh has begun to consider these issues at a very rudimentary level. It has formed a Ministry of Environment and Forests (formerly there was no such ministry) and a Department of Environment (formerly the Department of Environment Pollution Control). However, all these efforts are at a very early stage and much more needs to be done.

Future Work and Research Needs

Raising the Issue Internationally

As stated earlier Bangladesh cannot cope with the consequences of sea level rise on its own and therefore needs to raise the issue at all the appropriate international fora including the United Nations, the Climate Convention Protocols and other international meetings. Bangladesh's case in such meeting is that Bangladesh's contribution to Greenhouse gases is almost negligible while other countries, particularly the developed countries of Europe and North America make a relatively large contribution to such gases. Thus they should bear the onus of helping Bangladesh to cope with the consequent sea level rise.

Local Initiatives

Local level initiatives to sensitise government and people about the issues involved and possible dangers and solutions are essential. Adoption of policies and laws restricting habitation and investment in vulnerable areas may be necessary. However, implementation of such laws will be extremely difficult as the pressure on land regardless of how vulnerable is so great that people will inhabit and cultivate land which they know has a high probability of flooding annually, let alone inundation over decades.

Traditionally also loss of land due to river and sea erosion has been lot of the people of the country and laws and practices regarding such loss by erosion and gain by accretion have evolved over time. Similar practices of the people in the face of ecological and environmental change need to be studied and assisted where possible.

Study of Coastal Ecosystems

The different coastal ecosystems including the mangrove forests need to be studies in greater depth in order to see whether adaptation or an accelerated land accretion may be possible.

International Scientific Cooperation

Although there are many capable scientists in Bangladesh, they lack the resources to carry out the studies needed. It would be useful for them to be able to collaborative studies on issues such as accurate determination of the actual relative sea level rise, taking the land subsidence into account, using satellite measurements.

Manpower Development

As the problems of climate change and sea level rise are likely to take place over decades it is necessary for Bangladesh to develop the necessary skilled manpower to study and tackle the problems that are likely to arise. This will require identification of the skills which will be needed and a plan to develop these skills over time.

Develop Appropriate Policies

The government needs to consider the problem of climate change and sea level rise more thoroughly and develop appropriate policy options to mitigate the effects such as protection of coastal infrastructure, relocation of people, etc.

Conclusion

The people of Bangladesh have been living with natural hazards and catastrophes for thousands of years and have developed methods of coping with them. However the threat of sea level rise due to man made climate change is something that is new and potentially devastating. They will need the assistance of the world community in order to face this new problem.

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CHAPTER SEVEN

NATURAL DISASTERS

M.A.H. Pramanik

Introduction

Bangladesh is a disaster-prone country. The physiography, morphology and other natural conditions have made her vulnerable to disasters and environmental hazards. The major elements in the process are:

- Floods.
- Cyclones and storm surges.
- Droughts.
- Abnormal rainfall, hailstorm and lightning.
- Nor'westers and tornadoes.
- Erosion and landslides.
- Earthquakes.
- Saline intrusion.
- Industrial and other pollution.
- Deforestation and depletion of forests.
- Environmental degradation and hazards connected with ecological imbalances.
- Causes and effects of greenhouse gases, global warming, sea level rise and depletion of ozone layer.
- Effects of El-Nino-Southern Oscillation (ENSO) and other climatic changes/variabilities/anomalies.

The causes and effects caused by them singly or in combination with one another, may result in direct loss of life and physical property requiring large

resources in disaster control and prevention. The consequences of these environmental hazards pose a threat to the economic development of the country. This calls for an effective disaster warning and dissemination system. The timely and accurate alert system of the impending disasters will help reduce the loss of life and property.

In the present paper, an attempt has been made to throw some light on some of the disasters. In order to put the problem into perspective, a review of the geographical setting, physical characteristics, river morphology and other salient features of Bangladesh, a part of the Bengal Basin, is first provided.

Geographical Setting

Bangladesh has an area of about 144,000 sq. km. and a population of more than 100 million. Bangladesh is situated in the north-eastern part of the South-Asian continent between latitudes 20°34' and 26°38'N and longitudes 88°01' and 92°41'E, (BBS 1989). The country has a vast area to the south, in the Bay of Bengal having an economic zone of the order of 100,000 sq. km. (Rashid 1989). The country comprises the eastern portion of the Ganges-Brahmaputra delta which stretches northward to the foothills of Assam. This is the largest delta in the world, formed by the Ganges, the Brahmaputra and the Meghna. These three rivers have a huge catchment area of some 1,554,000 sq. km. spread over five countries namely Bhutan, Nepal, China, India and Bangladesh. The number of rivers, canals and streams in Bangladesh is about 230 with a total length of some 24,135 km. which occupies a riverine area of about 9,384 sq. km. (BBS 1979, 1980). This delta is characterized by flat terrain, interlaced with an intricate system of rivers and tidal channels which carry downstream an enormous quantity of sediment laden water. The main river system occupying the delta is formed by the Ganges and the Brahmaputra which are known as the Padma and the Jamuna respectively, once they enter Bangladesh. The Jamuna joins the Padma near Aricha and flows up to Chandpur. The Padma falls into the Meghna near Chandpur and the combined flow is called the Meghna which empties into a large estuary (known as the Meghna estuary) at the north-eastern apex of the Bay of Bengal. The rate of total outflow to the Bay of Bengal through Bangladesh varies from 103,900 m^3/s in August to 8,780 m^3/s in February (Shahjahan 1988). When the holding capacity of rivers,

khals, beels, haors, low-lying lands is exceeded, flood occurs. Flood is more or less a recurring phenomenon in Bangladesh and often within tolerable limits. Occasionally, it becomes devastating. In 1988, Bangladesh faced an unprecedented flood, causing massive loss of life and property.

Alongwith the flood water, huge amount of sediments estimated to be 2.4 billion tons/year (Holeman 1968, Coleman 1969 and Khan 1978) are carried by the river system in Bangladesh. These sedimentations are subjected to coastal dynamic processes generated mainly by river flow, tide and wind actions. The ultimate result may be additional new land in some places due to accretion and loss of land in other places due to erosion. The problem of sedimentation, *chars* (islands) formation/accretion, erosion etc. plays an important role in the siltation of the water-holding capacity of rivers. The deterioration of the river system due to siltation is one of the causes of floods in Bangladesh. In addition, the undesirable *chars* in the river system threaten inland water navigation, cause erosion of the river-banks and create other socio-economic problems in the area.

Characteristics of the Bengal Basin and Bangladesh Area

The Bengal Basin is one of the largest geosynclinal (a large depression or trough in the earth's crust) basins in the world. The Basin is bordered on the north by the lofty Tertiary Himalayas, on the north-east and east by the late Tertiary Shillong Plateau, Tripura hills of lesser elevation and Naga-Lusai folded belt and ancient Chhotanagpur plateau of moderate height in the west. The southern fringe of the basin is not distinct, but the geophysical evidence indicates that it is open towards the Bay of Bengal for a considerable distance. The formation and growth of the Bengal Basin are directly related to the origin and morphology of the Indo-Gangetic trough which itself is overlaid and filled by sediments thousands of metres thick.

The Bengal Basin is floored with Quaternary sediments deposited by the Ganges, Brahmaputra and Meghna rivers and their numerous tributaries and distributaries. The sediments are washed down from high lands on three sides of the Basin, particularly, from the Himalayas, where the slopes are steeper and the rocks are less consolidated.

Broadly-speaking, the soils of the Bengal Basin can be grouped into three major physiographic divisions: hill soils (12 per cent), old alluvial soils

(8 per cent) and recent alluvial soils (80 per cent). The hill soils occupy the Himalayan ranges, Chittagong hills, the low hills and hillocks of Sylhet. They are derived from Tertiary rocks and unconsolidated Tertiary and Pleistocene sediments. Old alluvial soils include the tracts of the Modhupur and Barind. The soils of these two tracts have been formed on the old alluvium of the Pleistocene epoch and are typically reddish to brownish in colour. In addition to these two major Pleistocene terraces, two other minor terraces flank the basin, one is to the east of the Rajmahal Hill system and the other is to the west of the folded Tripura Hills (Figure 1).

Recent alluvial soils are found in the Gangetic alluvium, Teesta silt, Brahmaputra alluvium and coastal saline tracts. Gangetic alluvium has been formed by the deposits of the Ganges and many of its tributaries. These soils are rich in calcium, magnesium, potassium and free calcium carbonate. The soils in the Brahmaputra alluvium tract include samples of all the fully inundated areas in the region of active rivers. The coastal saline tract is a part of the active flood plain, but is subject to flooding with saline water at high tides. This tract includes the southern parts of Khulna, Barisal and Patuakhali regions (old districts) and the islands and coastal area of Noakhali and Chittagong regions (old districts). The soils of the coastal districts have some localized variations, both areally and stratigraphically, but consist primarily of fine sands, silts, silty sands, sandy silts and clayey silts.

The broad geological features of the Bengal Basin and its prominent tectonic elements are Indian Platform, Bengal foredeep, Arakan Yuma folded system and the Sub-Himalayan foredeep. Other features are Rangpur Saddle, Dinajpur slope, Bogra slope, Hinge zone, Barisal High, Troughs of Sylhet, Faridpur and Hatiya etc. (Bakhtine *et al.* 1966, Guha 1978 and Zaher *et al.* 1980) (Figure 2).

A few large depressions, *beels* are seen on the delta. The *beels* are usually scars and ox-bow lakes or back-lands of old river-beds but tectonic subsidence is also regarded as one of the causes of the origin of the basins. These major *beels* are the *haor* area (4450 sq. km.) in Sylhet-Mymensingh, the Chalan *beel* area (363 sq. km.) in Rajshahi-Pabna, and a *beel* in the Gopalganj area in Faridpur region (1160 sq km.). Detailed discussions on the characteristics of the Bengal Basin area are available in (Chowdhury 1969, Morgan and McIntire 1959, Islam 1964, Ahmad 1968, Coleman 1969, Kibria 1970, Hoque 1974, Rashid 1977, Jabbar 1978, Pramanik 1983 and Rasid and Pramanik 1990).

Figure 1

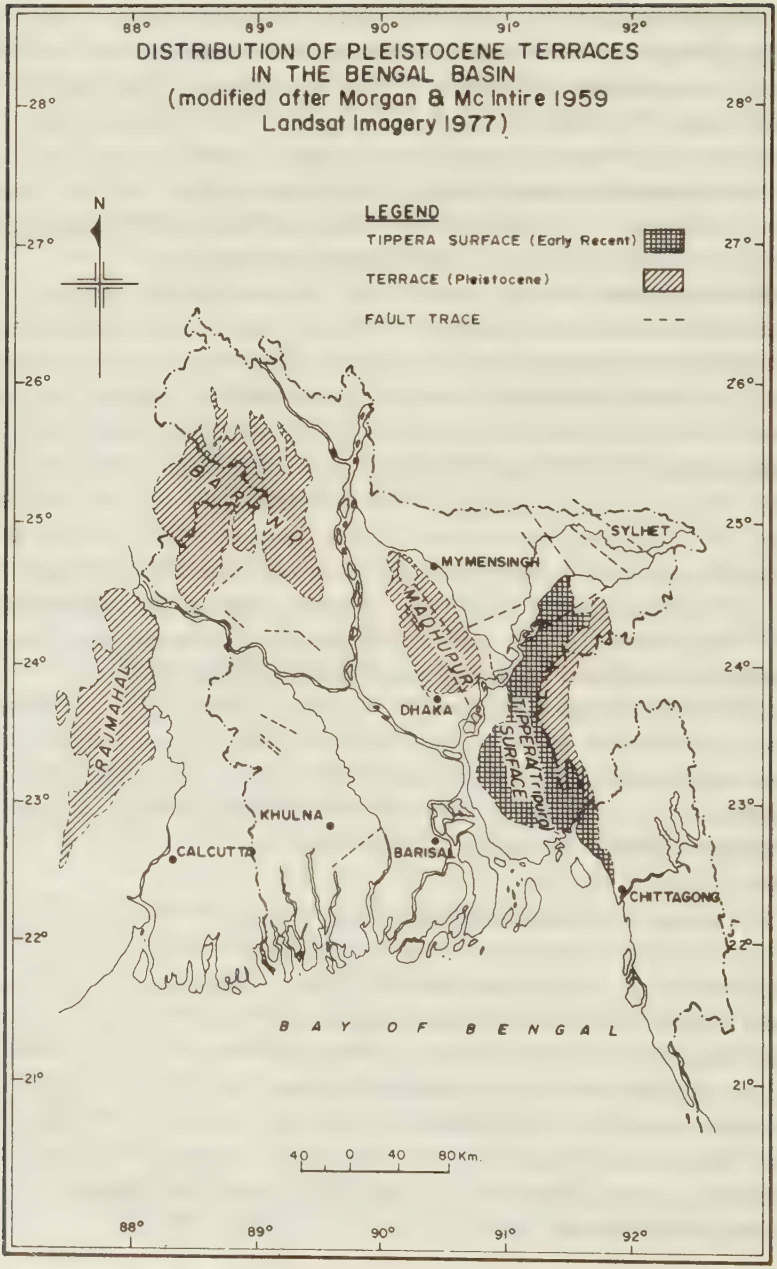
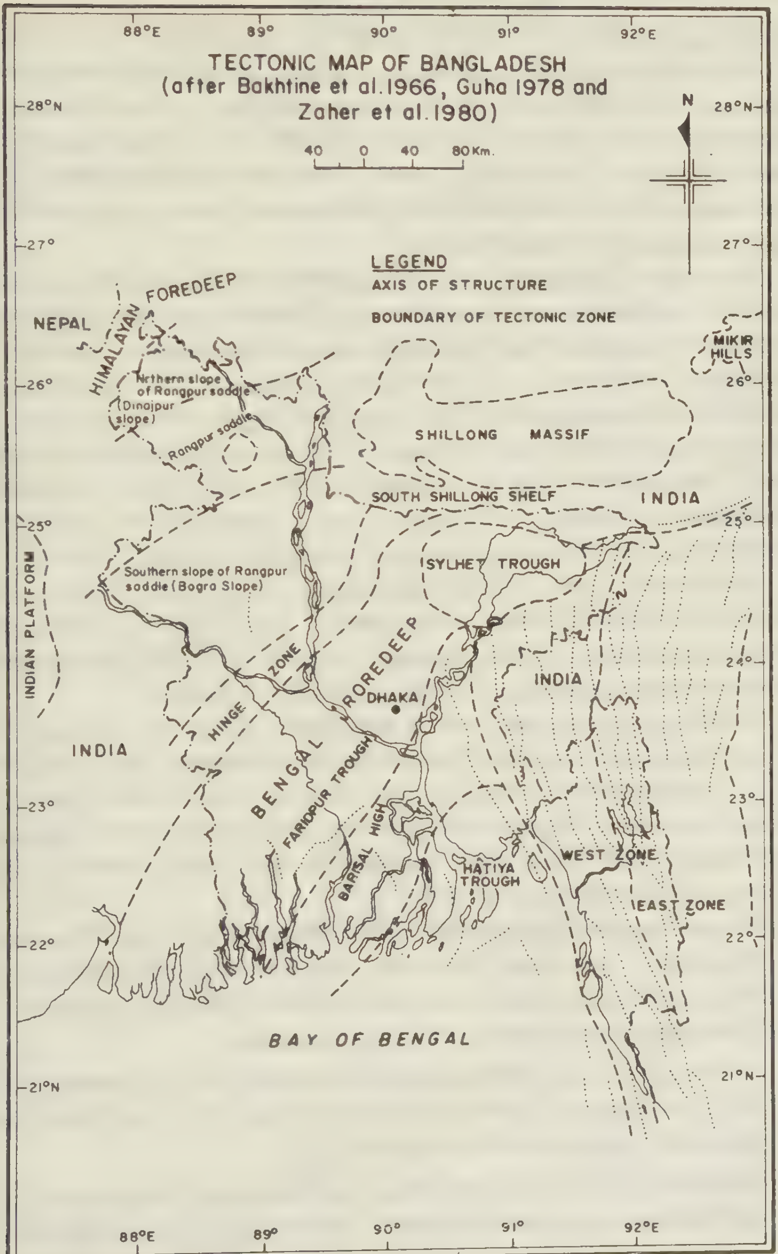

DISTRIBUTION OF PLEISTOCENE TERRACES
IN THE BENGAL BASIN
(modified after Morgan & Mc Intire 1959
Landsat Imagery 1977)
LEGEND
TIPPERA SURFACE (Early Recent)
TERRACE (Pleistocene)
FAULT TRACE
N
BARIND
MADHUPUR
RAJMAHAL
TIPPERA SURFACE
SYLHET
MYMENSINGH
DHAKA
KHULNA
CALCUTTA
BARISAL
CHITTAGONG
BAY OF BENGAL
40 0 40 80 Km.
88° 89° 90° 91° 92°
28° 27° 26° 25° 24° 23° 22° 21°

Figure 2


TECTONIC MAP OF BANGLADESH
(after Bakhtine et al.1966, Guha 1978 and Zaher et al.1980)
40 0 40 80 Km.
N
LEGEND
AXIS OF STRUCTURE
BOUNDARY OF TECTONIC ZONE
88°E
89°
90°
91°
92°E
28°N
27°
26°
25°
24°
23°
22°
21°N
HIMALAYAN FOREDEEP
NEPAL
Northern slope of Rangpur saddle
(Dinajpur slope)
Rangpur saddle
SHILLONG MASSIF
SOUTH SHILLONG SHELF
MIKIR HILLS
INDIA
SYLHET TROUGH
Southern slope of Rangpur saddle (Bogra Slope)
INDIAN PLATFORM
HINGE ZONE
BENGAL FOREDEEP
DHAKA
FARIDPUR TROUGH
BARISAL HIGH
HATIYA TROUGH
WEST ZONE
EAST ZONE
BAY OF BENGAL

River Morphology in Bangladesh

The Bengal Basin is covered by a network of a large number of rivers, all of which eventually discharge into the Bay of Bengal. The bulk of water, however, passes through the Ganges-Brahmaputra-Meghna river system which is one of the largest systems in the world. The other rivers, except those in the south-eastern part of Bangladesh, are the tributaries and distributaries of this river system. This network of rivers controls the land forms, topography and cultural pattern of the Bengal Basin.

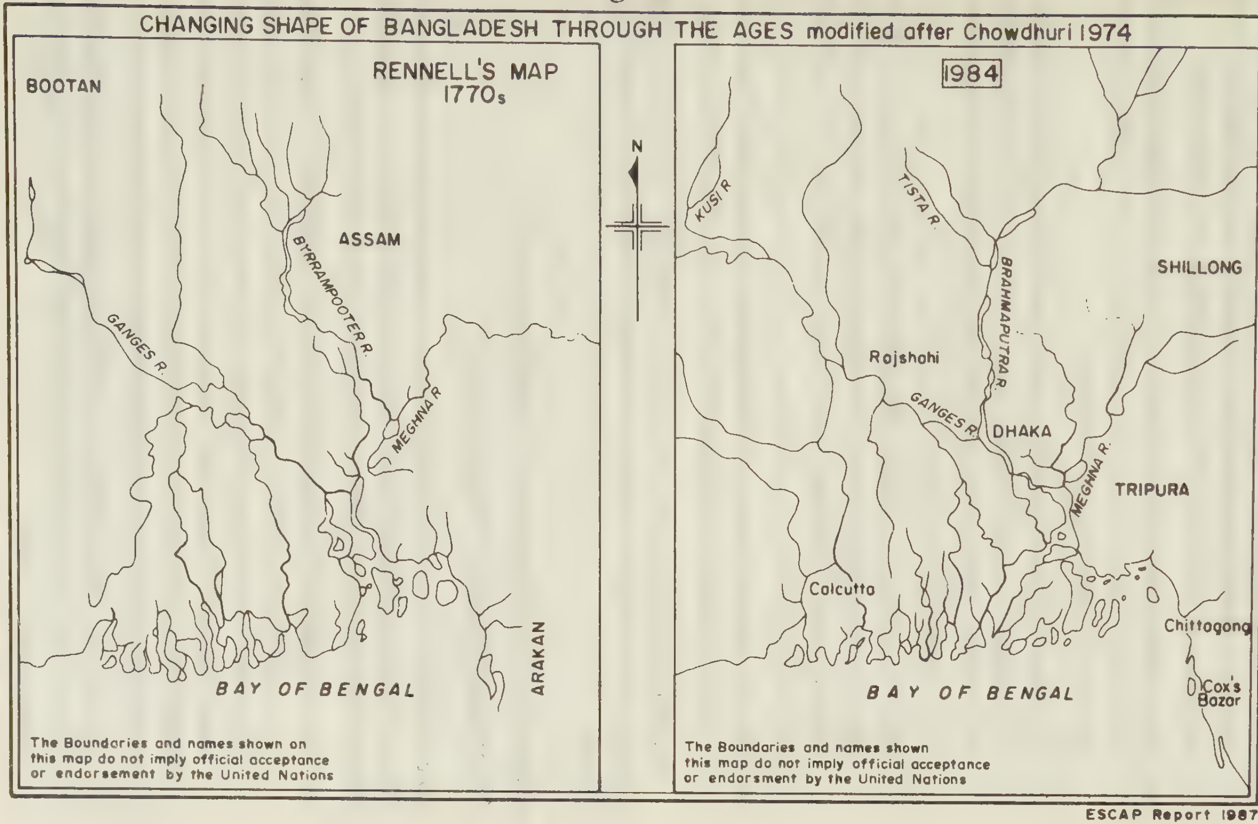
The Ganges, primarily a meandering stream, is about 2,600 km. long and flows parallel to the Himalayan range. It is fed mainly by rivers rising in the southern slopes of the Himalayas and enters Bangladesh at the western extremity of Rajshahi region. The Brahmaputra rises in Tibet and flows in an easterly direction north of the Himalayan range before turning south through the mountains; then it flows west down the Assam valley for a distance of about 700 km. and enters Bangladesh as a wide-braided river region near Majhiali in Rangpur. The Meghna river, a meandering one, drains the Sylhet Basin and parts of the adjacent Shillong Plateau and Tripura Hills. The Brahmaputra, when it enters Bangladesh, is known as the Jamuna which joins the Ganges (the Padma in Bangladesh), near Aricha. This combined flow meets the Meghna near Chandpur. The Padma and Meghna together flow into the Bay of Bengal. It is now known as the Meghna.

The hill rivers in the south-east of Bangladesh, namely Feni, Karnaphuli, Sangu, Matamuhuri and Naaf flow into the Bay of Bengal. The Karnaphuli is the longest (274 km.) and the most important river in this region. A detailed discussion of the river system in the Bengal Basin can be found in (Chowdhury 1959, Abbas 1964, Ahmad 1968, Khan 1975, Tarafdar 1975, Rashid 1977 and Hossain *et al.* 1987).

Dramatic morphological changes have occurred in the Bengal Basin due to shifting of river courses in the past. These changes are attributed to natural calamities like floods, cyclones, storm surges and earthquakes. A brief mention of some of the major changes are given:

- The change of course of the Teesta from the Ganges to the Brahmaputra during the flood of 1787 (Vas 1911, Chowdhury 1959, Rashid 1977 and Pramanik and Gafoor 1981) (Figure 3).
- Recurring floods in Rangpur, Bogra and Pabna districts between 1787 and 1830 accentuated the process of course changes of the Brahmaputra

Figure 3


CHANGING SHAPE OF BANGLADESH THROUGH THE AGES modified after Chowdhuri 1974
RENNELL'S MAP
1770s
BOOTAN
ASSAM
BYRRAMPOOTER R.
GANGES R.
MEGHNA R.
ARAKAN
BAY OF BENGAL
The Boundaries and names shown on
this map do not imply official acceptance
or endorsement by the United Nations
N
1984
KUSI R.
TISTA R.
BRAHMAPUTRA R.
SHILLONG
Rajshahi
GANGES R.
DHAKA
MEGHNA R.
TRIPURA
Calcutta
Chittagong
Cox's
Bazar
BAY OF BENGAL
The Boundaries and names shown
this map do not imply official acceptance
or endorsment by the United Nations
ESCAP Report 1987

from the old Brahmaputra, which flowed past Mymensingh town and joined the Meghna at Bhairab Bazar, to the Jhenai, later developed into the Jamuna (Chowdhury 1959, Ahmad 1968 and Al-Husainy 1976).

- The gradual shifting of the courses of the Ganges from the Hooghly to the present course is controversial (Chowdhury 1959, 1964, Morgan and McIntire 1959 and Coleman 1969).
- The Ganges (Padma) flowed separately to the Bay of Bengal through Tetulia channel during Rennell's survey (1764-1772). It has changed to its present course by joining the Meghna near Chandpur (Chowdhury 1959, Ahmad 1968 and Chowdhury 1979).
- The 1762 earthquake uplifted the Modhupur tract creating the Sylhet basin through subsidence compensatory to the elevation of the Modhupur tract (Fergusson 1863, Morgan and McIntire 1959). This is also controversial.
- The earthquake of Assam in 1950 has caused a change in the Swatch of No Ground and other deep seated rift valleys in the Basin (Kibria 1970).

The flat topography of the Basin and the occurrence of recurring floods causing course changes of rivers have complicated the river morphology pattern.

Other Salient Features of the Physical Characteristics of Bangladesh

To understand the complex and diverse environmental and economic conditions of Bangladesh, some information on salient features of the physical characteristics and a few economic indicators on Bangladesh are necessary.

- The topography of the Bangladesh area is extremely flat with local relief ranging between 1 and 2 m. At least 20 per cent of the area of the country consists of low-lying tidal plains with elevations of less than 3 m. above sea level. Due to the flat terrain, rivers have extremely low gradients (e.g. 4-5 cm./km. for the Ganges, 6-10 cm./km. for the Brahmaputra and 3 cm./km. for the Meghna) (Rasid and Pramanik 1990).
- There are 20 physiographic units and 30 agro-ecological zones classified broadly on the basis of agricultural and other land use patterns (Brammer *et al.* 1988).

- Bangladesh enjoys sub-tropical monsoon climates with three prominent seasons, winter (Nov.-Feb.), summer (March-June) and monsoon (July-Oct.) (BBS 1989 and Karmakar 1989).
- Land is highly fertile but agricultural production is very much weather dependent.
- Densely populated country with a population density of 737 persons/km^2. (Total population 106.1 million (mid-1987) and area 144,000 sq. km.) and the per capita daily caloric supply is 1927. Life expectancy at birth (in 1987) was 51 years (BBS 1989 and World Bank 1989).
- Development issues like poverty, population growth (2.36 per cent per annum), and the environment are almost identical with other Third World developing countries. Average annual growth (GDP) rate is 3.8 per cent (1980-1987) and rate of inflation is 11.1 per cent (1980-1987). Bangladesh is among the low-income economic group and belongs to the South Asian geographic region with a per capita GNP of US$ 160 and a 0.3 per cent (1965-1987) annual growth rate (BBS 1989 and World Bank 1989).

The geographical setting and the economic complexities of Bangladesh have been complicated by natural disasters of varied nature. The lofty Himalayas in the north and the funnel-shaped Bay of Bengal in the south have made Bangladesh a meeting place of the life-giving monsoon rains and the catastrophic ravages of floods, cyclones, storm surge, droughts etc. This disaster-prone country, in spite of the fertile land, network of rivers, sub-tropical monsoon climate and hard working people, is subject to food shortages because of heavy dependence of agricultural production on the vagaries of weather and natural disasters. In the following section, an attempt has been made to elaborate some selected natural disasters.

Floods

Bangladesh is a land of rivers and heavy monsoon rains. This is subject to inundation by overbank spills due to drainage congestion, rainfall run-off and storm-tidal surges. Some 30 to 35 per cent of the total land surface is flooded every year during the wet monsoon (Hossain *et al.* 1987 and Milliman *et al.* 1989).

During the peak flow season (July, August and September), most of the rivers overflow their banks and deposit silt on the flood plains, providing vital moisture and fertility to the soil. Thus the normal floods are considered as a blessing for Bangladesh. Only the abnormal floods i.e. the high-magnitude events that inundate large areas and cause widespread damage to crops and properties are considered hazardous.

The peculiar geographic location of the Bangladesh area has subjected her to flooding from time immemorial. The vast flooding of Rangpur district in 1787 reportedly changed the course of the Teesta from the Ganges to the present channel meeting the Brahmaputra (Jamuna) near Chilmari. The recurring floods of Rangpur, Bogra and Pabna regions (old districts) between 1787 and 1830 have accentuated the change of course of the Brahmaputra (Jamuna) from the old Brahmaputra to its present channel. The emergence of the Gorai-Madhumati as an important distributary of the Ganges in the early part of the 18th century contributed to occurrence of severe floods in Jessore, Faridpur, Kushtia and Khulna regions (old districts). There are, in addition, records of major floods in 1926 in the western part of Bogra and Pabna. The district of Mymensingh was severely ravaged by floods in 1938. Since 1947, a number of severe floods have occurred and caused damages to both life and property (Vas 1911, Morgan and McIntire 1959, Al Hussainy 1976, Rashid 1977, Hossain *et al.* 1987, Miah 1988 and Ali *et al.* 1988).

Mahalanobis (1927) dealt with the occurrences of rainfall and flooding in North Bengal (the then Bengal Presidency) during the period 1870-1922 and made a statistical analysis of the available data. Floods during 1870-1922 which inundated the Bangladesh area were:

Table 1

1870	Rajshahi and Pabna	moderate
1871	Rajshahi	severe and extensive
1874	Rajshahi and Pabna	moderate
1885	Rajshahi and Dinajpur	severe
1892	Rangpur and Dinajpur	very severe
1918	Rajshahi, Bogra, Dinajpur, Rangpur and Pabna	severe
1922	Bogra, Rajshahi, Pabna and Dinajpur	very severe and extensive

Historical records of minor flooding in the Bangladesh area till 1954 are not complete. However, the earlier information was given on available data.

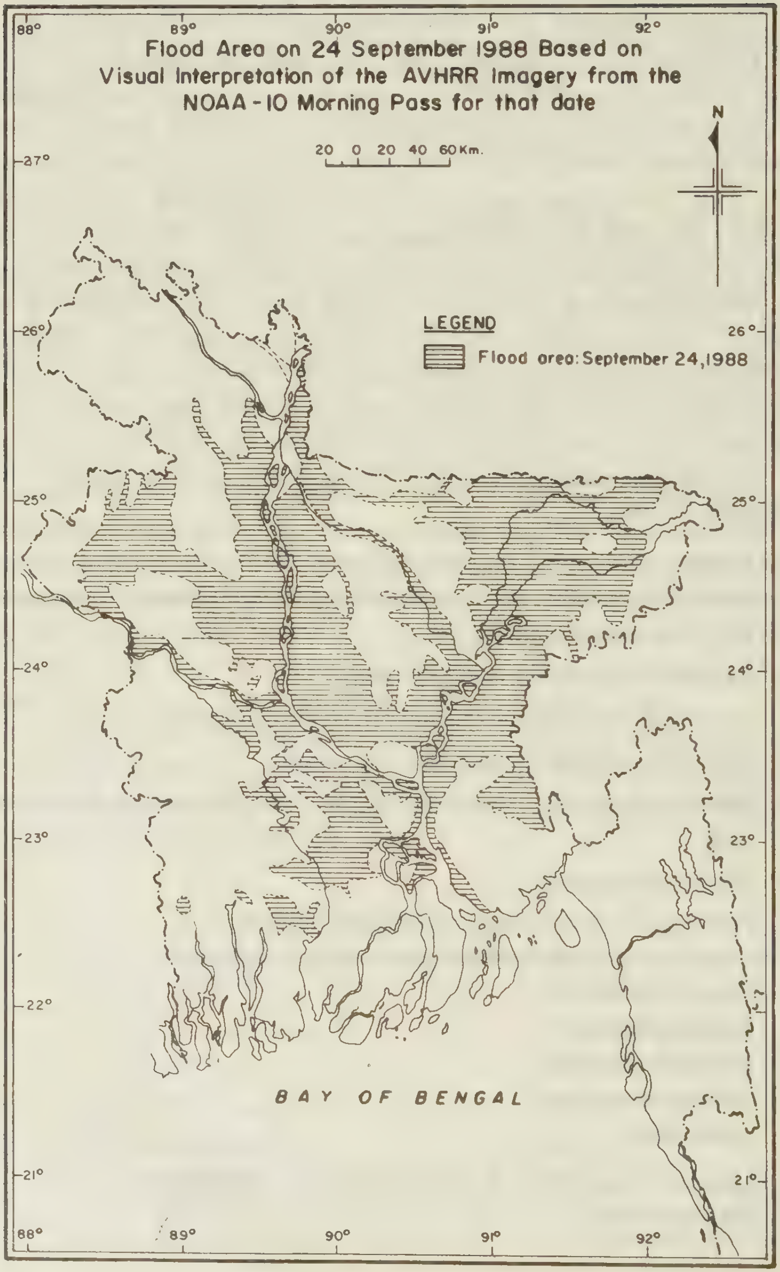
A statistical review has been given by (Miah 1988) showing the flood affected areas from 1954-1987. The extent of flooding areas were identified as (1954) 25.64 per cent area of the country, (1955) 35.21 per cent, (1963) 29.97 per cent, (1968) 26 per cent, (1969) 28.89 per cent, (1970) 29.61 per cent, (1971) 25.33 per cent, (1974) 36.61 per cent and 39.92 per cent (1987). The 1988 flood was devastating and unprecedented in recorded history, causing colossal damages to crops, lives and properties. The extent of 1988 flooding was widespread covering more than three fourths of the country. Extensive studies by various authors; (Bashar 1988, Choudhury 1988, Matin and Husain 1988, Pramanik 1988 and Rasid and Pramanik 1990) have shown that the area of flooding at different times, varied from 31 per cent to 85 per cent of the total area of the country (Figure 4).

The possible causes of floods in Bangladesh may be attributed to the following factors:

- General low topography of the country with major rivers draining through Bangladesh. (Ganges-Brahmaputra-Meghna) including congested river network system.
- Rainfall in up-country and in-country.
- Snow melt in the Himalayas and glacial displacement (natural).
- River siltation/lateral contraction/landslides.
- Synchronization of major river-peaks and influences of one river on the other.
- Human interference:

  Deforestation and denudation in the catchment area
  Construction of unplanned roads, bridges, housing etc.
  Flood embankments
  Storage reservoirs
  Diversion structures
  Drainage congestion
  Overgrazing.
- Tidal and wind effects on slowing down the river outflow (back water effect).

Figure 4


Flood Area on 24 September 1988 Based on
Visual Interpretation of the AVHRR Imagery from the
NOAA-10 Morning Pass for that date
20 0 20 40 60 Km.
N
LEGEND
Flood area: September 24, 1988
BAY OF BENGAL
88°
89°
90°
91°
92°
27°
26°
25°
24°
23°
22°
21°

- Effect of sea-level rise.
- Possible rise in sea-bed and land subsidence.
- Tectonic anomalies (earthquakes, change in river flow/morphology, rise in watersheds/catchment area).
- Possible greenhouse effect and depletion of ozone layer.
- Experiments on melting of glaciers in the Himalayas (artificial).

The study of these factors needs critical analysis/weightage over one another to substantiate and identify the decisive factors. It may be noted that there are certain common factors responsible for flooding in Bangladesh. The severity and intensity of flooding for a particular year depends on a number of factors which dominate over other factors. To cite examples, it may be mentioned that the devastating and unprecedented flood of 1988 has been caused mainly due to:

- Excessive rainfall in the catchment area in the last week of August substantiated by satellite imagery.
- Synchronization of the peak water-levels of all the major three rivers of Bangladesh.
- Solar eclipse of 11 September 1988 retarded the outflow of water drainage by raising the tidal level.
- Earthquake of 21 August 1988 may have caused tectonic anomaly in the Himalayan region.
- Deforestation in the upper catchment and sedimentation in the river-bed.

An analysis of hydrographs and other hydrological data of a few selected stations indicate the following salient features (Matin and Husain 1988):

- The synchronization of floods of major rivers for the years 1954 (30 days), 1974 (27 days), 1987 (30 days) and 1988 (3 days). It accentuated the disastrous and catastrophic flood of 1988.
- Frequency analysis of flood level of the Brahmaputra at Bahadurabad and Sirajganj, the Ganges at Goalundo had a return period of about 100 years. The flood level of the Buriganga at Dhaka and the Sitalakhya at Narayanganj had a return period in the order of 50 years.
- During 1987, there had been an abnormally high rainfall throughout the country, whereas during 1988, a very high rainfall in the upper catch-

ment area occurred. During the 1988 flood, 8 out of 10 stations in the Brahmaputra basin exceeded the flood level of 1987 and for the Ganges basin, that occurred for 5 out of 9 stations. The flood level of the Ganges upstream of Hardinge bridge was higher in 1987 than in the 1988 flood. Flood flow of the Ganges was also higher in the 1987 flood. In addition, in the south-eastern hill basin, the flood level of all the streams were higher in 1987, than in 1988. During 1987, an area of 57,270 sq. km. was inundated whereas in 1988, an area of 81,831 sq. km. was inundated.

It is felt that floods cannot be stopped but appropriate measures could be taken to mitigate, adapt and prepare to live with floods. A combination of a number of elaborate steps and actions will help in mitigating the suffering caused by floods. A few suggested actions/measures for flood mitigations are given:

- Construction of dams and reservoirs in the up-stream.
- Construction of embankments, barrages etc.
- Dredging, deepening and training of rivers including straightening.
- Massive afforestation programme.
- Raising the levels of roads and highways with sufficient openings and other infrastructural facilities including houses/schools/vegetated grounds etc.
- Excavation of old river beds/*beels*/ponds/*haors*/*baors* etc.
- Flood by-pass arrangement wherever appropriate.
- New ponds in old river beds/low-lying areas.
- Mass mobilization/voluntary work force/FWP etc.
- Change in cropping patterns and food habits.
- Replacing broadcasting *aman* with *aus* (traditional practice in some areas).

In addition, utilization of the latest development and state of-the-art scientific and technological levels may be explored by regional countries for in-depth study and joint research projects related to flood problems and

suggestions for permanent solutions to the problem in the future. While negotiating for regional cooperation, national efforts may be initiated immediately. Remote sensing activities may include updating of the technology, procurement of software and development of models for quantification of rainfall estimate, studies of snow melting from satellite imagery, introduction of a Geographic Information System (GIS), arrangements for making high resolution satellite data (Landsat/SPOT ground station) operational and procurement of survey aircraft with necessary accessories. Additionally, a long-term water policy is needed to be formulated to mitigate floods and to combat droughts; two diagonally opposite facets of water resources in the country.

Cyclones and Storm Surges

The term cyclone is derived from the Greek work *Kyklos* meaning coil of snakes. Satellite imagery showing the cyclonic formation depicts the 'coil of snakes' like-pattern, as in Figure 9. Every year, there are some eighty tropical cyclones occurring around the globe, out of which about 4, (5 per cent) form in the Bay of Bengal (Crane 1988). The average plus percentage of total (in bracket) number of formation of cyclones around the globe is shown in Figure 5. The formation, intensification and structure of tropical cyclones are related to six primary climatological genesis parameters which are:

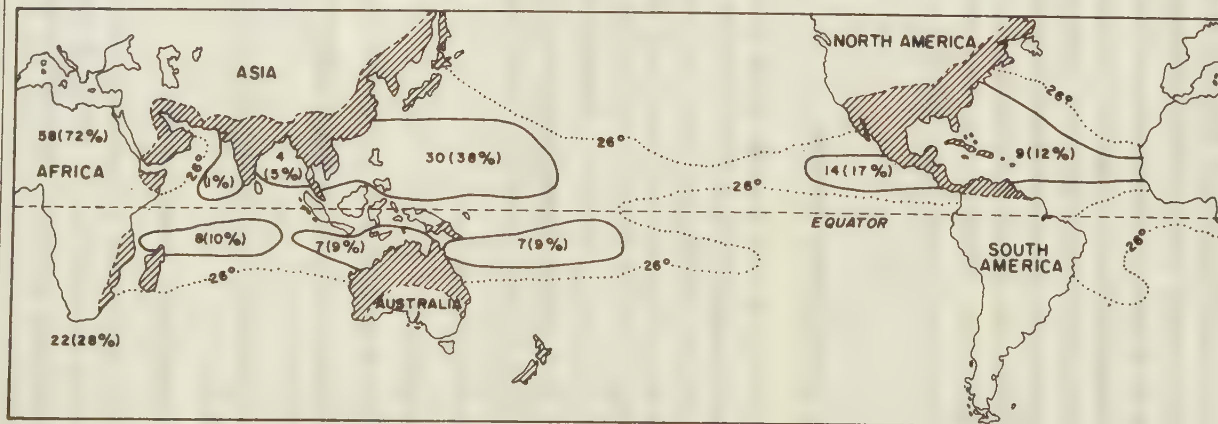
- Low level relative vorticity.
- Coriolis parameter.
- Weak vertical shear.
- Ocean thermal energy-sea surface temperature excess of about 26°C to a depth of 60m.
- Vertical gradient of equivalent potential temperature between Surface and 500 mb.
- Middle tropospheric relative humidity.

Gray (1980) has defined a 'seasonal genesis parameter' (sgp) by taking the product of the above six parameters and has shown that empirical predictions with spg are in close agreement with observations of tropical cyclone formation.

Figure 5

FORMATION OF TROPICAL CYCLONES–AVERAGE
ANNUAL NUMBER PLUS PERCENTAGE OF TOTAL
(Modified after Crane 1988)

LAND AREAS AFFECTED BY TROPICAL CYCLONES



Crane (1988) mentioned that several specific conditions are necessary for the development of cyclonic formations and they must occur simultaneously as follows:

- Deep convection over a large area.
- Sea temperature above 26°C.
- Turning force due to earth's rotation (Coriolis force).
- Light winds up to about ten kilometres.
- Divergent winds aloft to provide ventilation.
- Rotation and inflow of wind at low altitude.
- High relative humidity up to about six kilometres.

Technically, a cyclone is an 'area of low pressure' where strong winds blow around a centre in anti-clockwise direction in the northern hemisphere and clockwise direction in the southern hemisphere. Cyclones occurring in the tropical regions are called tropical cyclones and those occurring outside the tropical regions are called extra-tropical cyclones. Tropical cyclones do not cross the equator or form within four or five latitude degrees of it, where the influence of the earth's rotation is negligible. This influence becomes greater with increasing latitude and acts in opposite directions in each hemisphere, causing the tropical cyclones to rotate clockwise in the southern hemisphere and anti-clockwise in the northern hemisphere.

Tropical storms are called *hurricanes* in the West Indies and the Atlantic coast of America; *typhoons* in the Far East and *cyclones* in Indo-Bangladesh Sub-continent. Actually, they are the same phenomena but are known by different names in different parts of the world (Choudhury 1974 and Crane 1988).

Tropical cyclones derive their energy from warm moisture of the sea and to sustain this energy, sea surface temperature needs to be at least 26°C. Tropical cyclones weaken over cooler water and more rapidly when moving overland. Low level winds must converge into an area of disturbed weather to provide some initial rotation. Developing tropical depression needs a continuing spiral inflow to supply momentum and water vapour to the spinning vortex (Crane 1988).

The Bay of Bengal is situated in the north-eastern corner of the Indian Ocean and is bounded between latitudes 5°-22° N and longitudes 80°-95°E. It

occupies an area of about 2.2 million sq. km. It is 1,609 km. wide with average depth of more than 792.5m. and maximum depth is 4,500m. (Encyclopedia Britannica 1980). The Bay of Bengal cyclones mostly originate at latitudes greater than 5°N (near the Andamans). It is presumed that the Inter-Tropical Convergence Zone (ITCZ) which is situated near the equator and where winds from the two hemispheres meet, plays a part in the formation of the tropical cyclones. The Bay of Bengal is the breeding place of catastrophic cyclones causing immense loss of life and property during pre-monsoon (April-May) and post-monsoon (Sept.-Dec.) periods. Cyclones in the Indo-Bangladesh Sub-continent are classified according to their intensity and the following nomenclature is used:

- Depression : winds up to 62 km./hour
- Cyclonic storm : winds up to 63-87 km./hour
- Severe cyclonic storm : winds up to 88-118 km./hour
- Severe cyclonic storm of hurricane intensity : winds above 118 km./hour

It has been observed from satellite images that a mature cyclone has got a well organized cloud pattern which acts as the indicator of wind-speed depending on its size and degree of organization. On this basis, cyclones have been divided into four categories:

Category 1 : Cloud pattern centre is poorly defined and cloud bands are poorly organized. No eye is visible and wind speed ranges from 48-80 km./hour.

Category 2 : Pattern centre is apparent, cloud pattern is quite organized. A wide break and a long tail may be present. No eye is visible and the wind-speed ranges from 64-128 km./hour.

Category 3 : Eye is usually visible but rugged and irregular in shape. The cloud is compact and tends to be circular. Wind-speed ranges from 80-200 km./hour.

Category 4 : Eye is prominent and circular; cloud pattern is almost circular and smooth. Wind speed ranges from 128-322 km./hour.

These types of classification have, however, been discontinued.

Presently, classification of cyclones from categories T1 to T8 at intervals of half an integral number has been made. This system of classification has evolved after simultaneous observation of tropical cyclones by both spacecraft and aircraft. During aircraft reconnaissance, various parameters like wind-speed, atmospheric pressure and temperature were measured at various locations of the Atlantic and the Pacific. By a mathematical analysis of the cyclone data of the Bay of Bengal, it has been shown that cyclone models of the Atlantic and the Pacific can be applied with reasonable accuracy to cyclones of the Bay of Bengal (Choudhury 1991).

A series of tracks of cyclones in the Bay of Bengal area is shown in Figure 6. Normally, it is observed that cyclones at their initial stages move at a rate of 8-16 km./hour and in their final stages they move at a rate of 24-32 km./hour or even up to 48 km./hour. In their movements, cyclones are supposed to follow the path of prevailing winds. Cyclones in the Bay of Bengal, usually move north-westerly in the beginning and then curve eastwards. But patterns are not uniformly followed as can be seen in Figures. 6 and 7. The cyclones usually decay after crossing the land causing colossal damages to life and property in the coastal region. Cyclones are accompanied by heavy rains and tidal waves called storm-surges which cause most of the damages. Storm surge heights are directly related to cyclone intensity. If the strength of the wind in a cyclone increases. the surge-height will also increase. Astronomical tides in combination with storm-surges lead to higher water-levels and hence severe flooding. It may be mentioned that an average of 1-5 severe cyclonic storms hit Bangladesh each year and the associated storm-surge, as much as 6m. higher than normal, can reach as far as 200 km. inland (Milliman *et al.* 1989).

Catastrophic cyclones occurred in the Bay of Bengal and hit Bangladesh area in the years; 1584, 1876, 1919, 1942, 1960, 1961, 1963, 1965, 1970, 1985 and 1988 (Choudhury 1974, 1987, 1988, 1991; Ali 1979, 1980; Choudhury and Karmakar 1986; UNDTCD/UWCRD 1987 and Karmakar 1989).

Some of the major cyclones affecting Bangladesh area are shown in Table 2 indicating dates, their maximum wind-speed and storm-surge heights.

Figures 8, 9, 10 show the satellite pictures of 29 April 1991 cyclone and its track (Choudhury 1991 and Kar 1991). Extent of natural disasters areas affected by floods of 1988 and cyclone of 1991 are shown in Figure 11 (Rashid 1991).

Figure 6

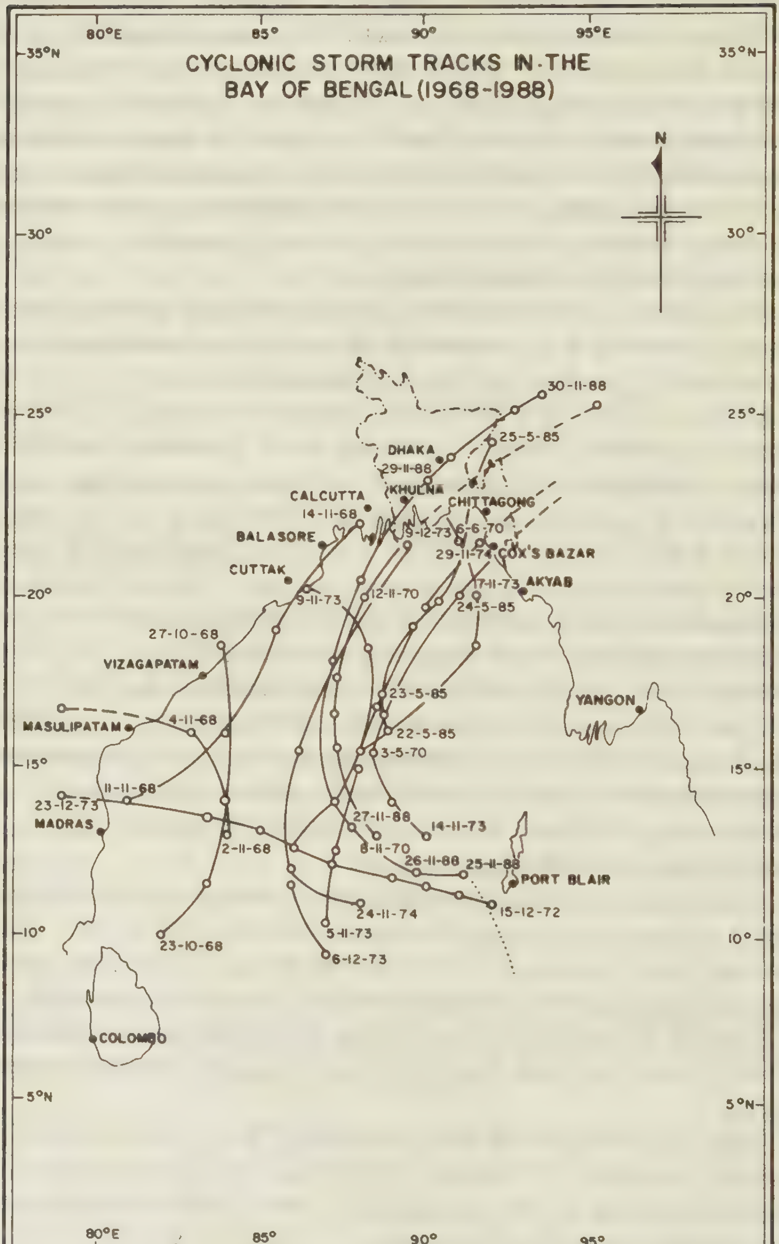

CYCLONIC STORM TRACKS IN THE
BAY OF BENGAL (1968-1988)
80°E
85°
90°
95°E
35°N
30°
25°
20°
15°
10°
5°N
N
DHAKA
29-11-88
KHULNA
CALCUTTA
14-11-68
CHITTAGONG
BALASORE
9-12-73
6-6-70
29-11-74
COX'S BAZAR
CUTTAK
17-11-73
AKYAB
9-11-73
12-11-70
24-5-85
30-11-88
25-5-85
27-10-68
VIZAGAPATAM
MASULIPATAM
4-11-68
23-5-85
YANGON
22-5-85
3-5-70
11-11-68
23-12-73
MADRAS
27-11-88
14-11-73
2-11-68
8-11-70
26-11-88
25-11-88
PORT BLAIR
24-11-74
15-12-72
5-11-73
23-10-68
6-12-73
COLOMBO

Figure 7

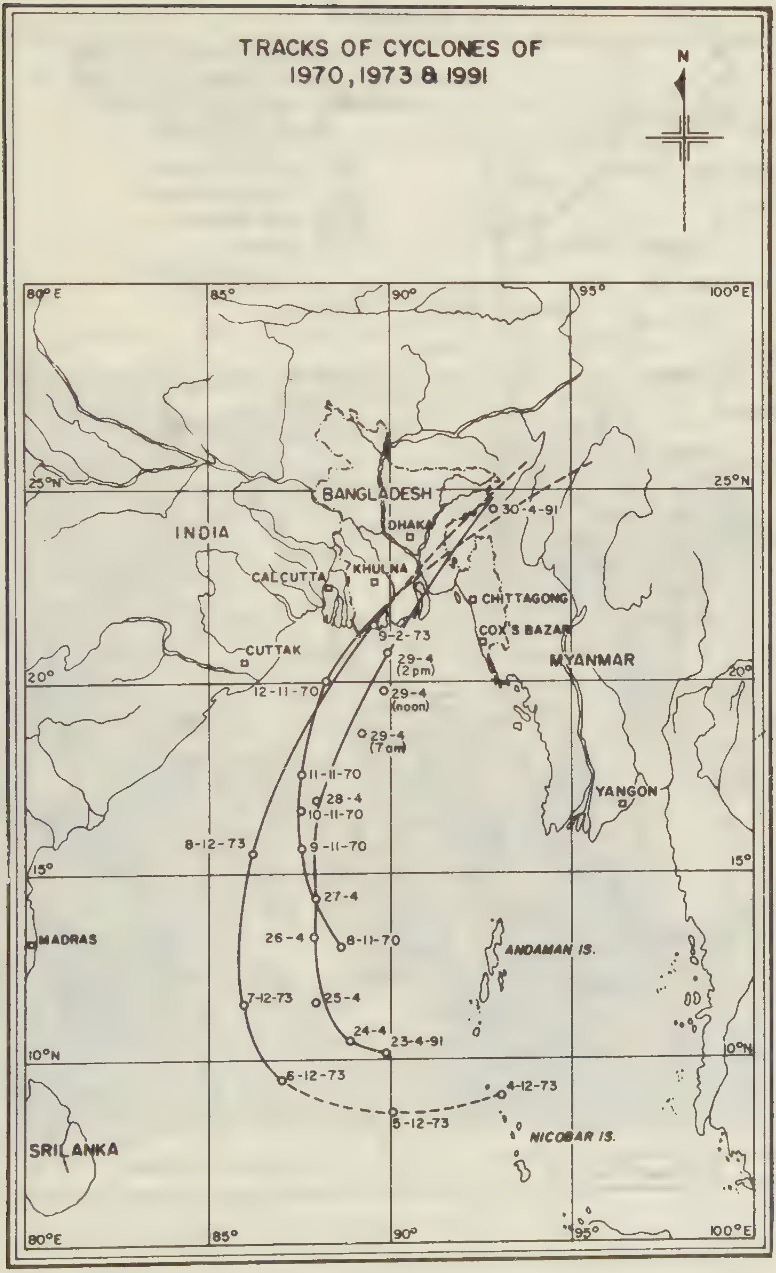

TRACKS OF CYCLONES OF
1970, 1973 & 1991
N
80° E
85°
90°
95°
100° E
25° N
20°
15°
10° N
BANGLADESH
INDIA
DHAKA
KHULNA
CALCUTTA
CHITTAGONG
COX'S BAZAR
CUTTAK
MYANMAR
YANGON
MADRAS
ANDAMAN IS.
NICOBAR IS.
SRILANKA
30-4-91
9-2-73
29-4 (2 pm)
12-11-70
29-4 (noon)
29-4 (7 am)
11-11-70
28-4
10-11-70
8-12-73
9-11-70
27-4
26-4
8-11-70
7-12-73
25-4
24-4
23-4-91
6-12-73
4-12-73
5-12-73

Figure 8

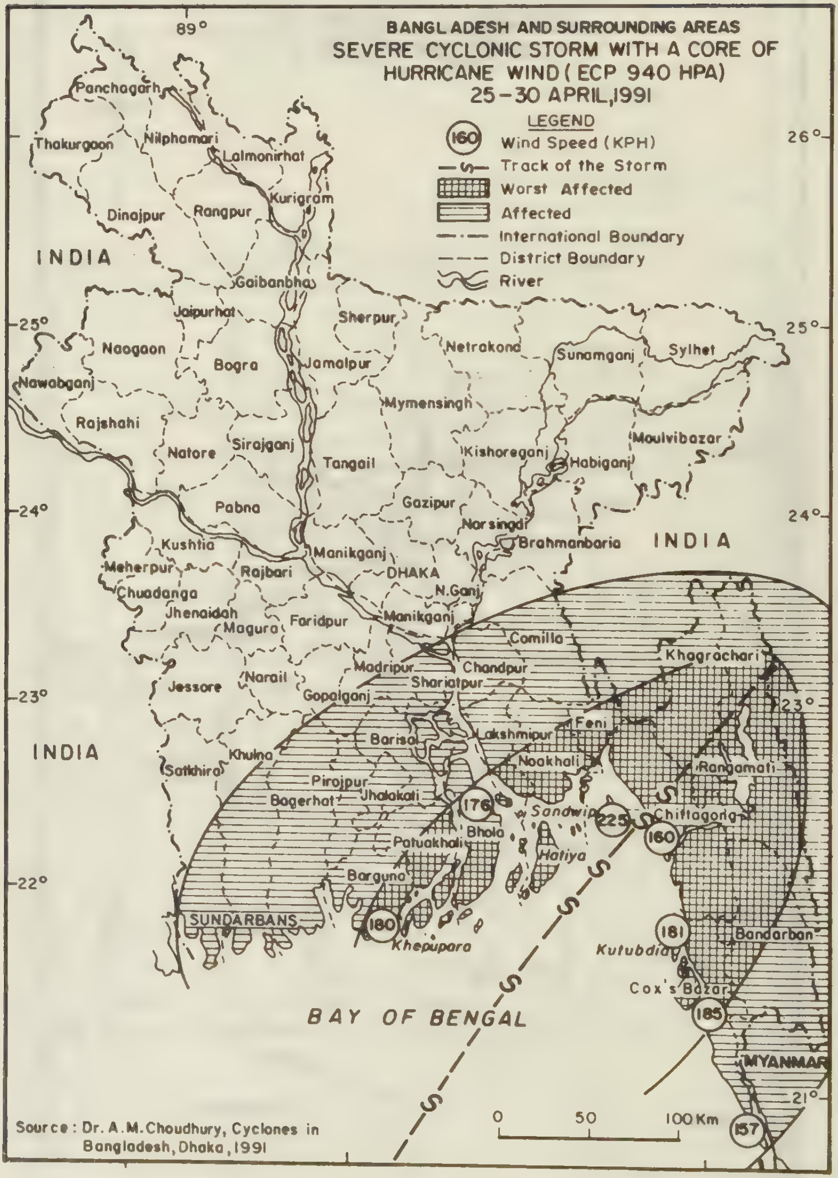
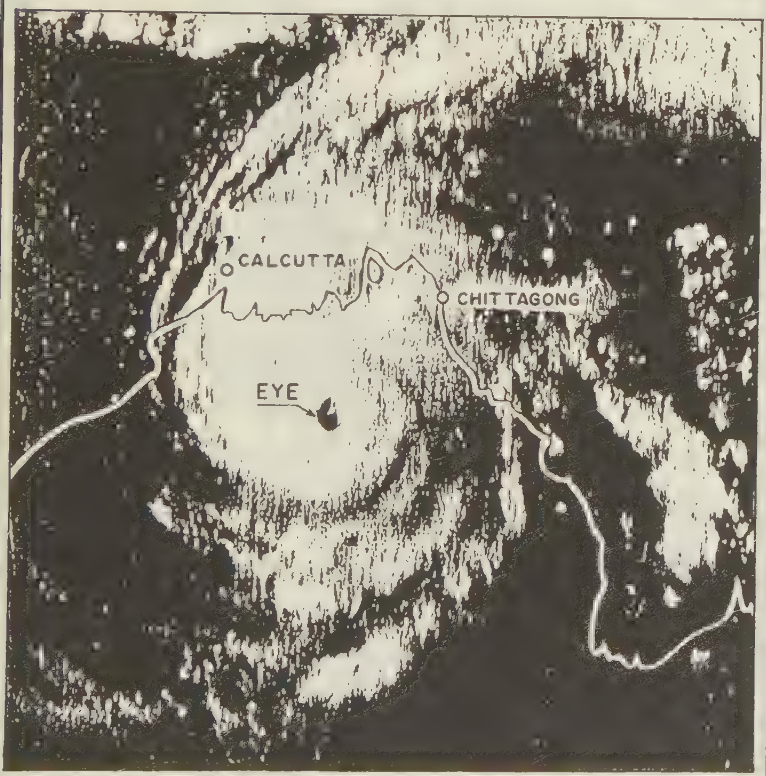

BANGLADESH AND SURROUNDING AREAS
SEVERE CYCLONIC STORM WITH A CORE OF HURRICANE WIND (ECP 940 HPA)
25-30 APRIL, 1991
LEGEND
160 Wind Speed (KPH)
Track of the Storm
Worst Affected
Affected
International Boundary
District Boundary
River
INDIA
INDIA
INDIA
BAY OF BENGAL
MYANMAR
SUNDARBANS
Panchagarh
Thakurgaon
Nilphamari
Lalmonirhat
Kurigram
Dinajpur
Rangpur
Gaibanbha
Joipurhat
Naogaon
Bogra
Nawabganj
Rajshahi
Natore
Sirajganj
Jamalpur
Sherpur
Netrakona
Sunamganj
Sylhet
Mymensingh
Kishoreganj
Habiganj
Moulvibazar
Tangail
Gazipur
Narsingdi
Brahmanbaria
Pabna
Kushtia
Meherpur
Chuadanga
Jhenaidah
Rajbari
Manikganj
DHAKA
N.Ganj
Manikganj
Magura
Faridpur
Comilla
Khagrachari
Madripur
Chandpur
Shariatpur
Narail
Jessore
Gopalganj
Barisal
Lakshmipur
Feni
Noakhali
Rangamati
Khulna
Satkhira
Pirojpur
Jhalakati
Bagerhat
176
Sandwip
225
Chittagong
160
Bhola
Patuakhali
Hatiya
Barguna
180
Khepupara
181
Kutubdia
Bandarban
Cox's Bazar
185
157
89°
26°
25°
24°
23°
22°
21°
0 50 100 Km
Source: Dr. A.M. Choudhury, Cyclones in Bangladesh, Dhaka, 1991

Figure 9

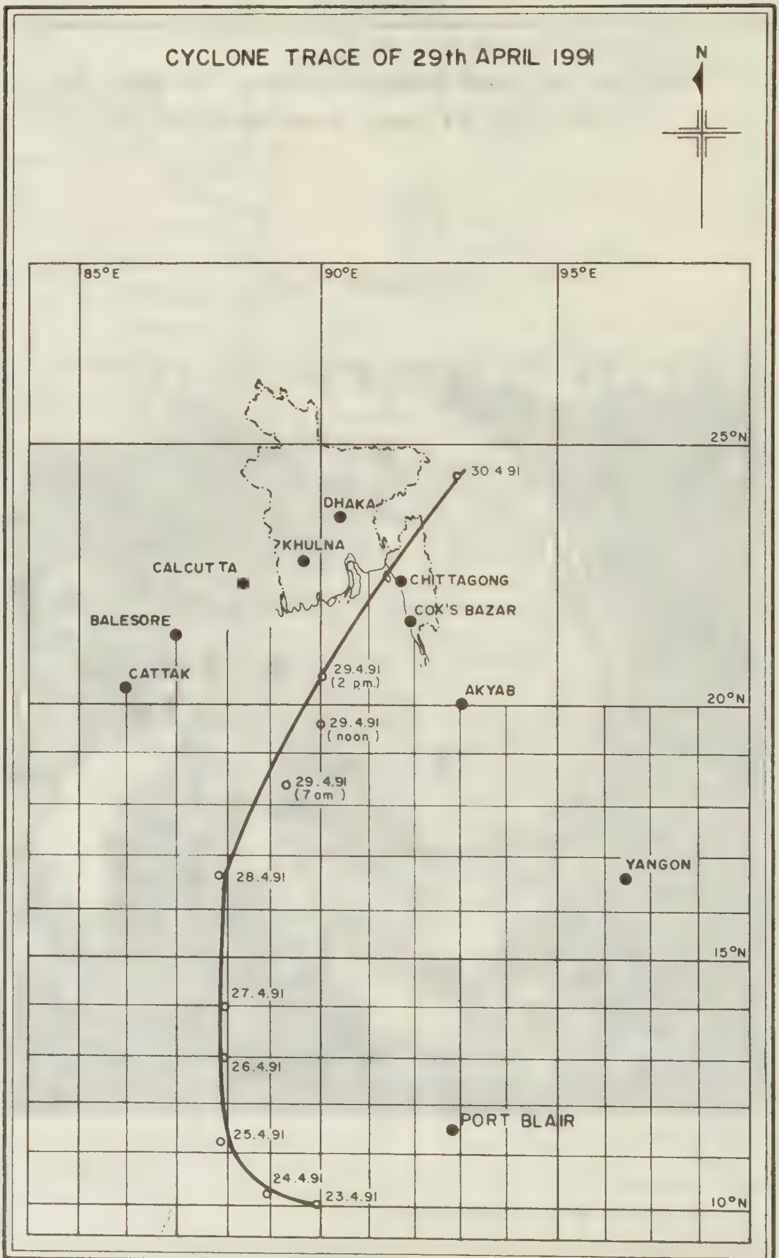
The "eye" as seen in the Cyclone of 29 April, 91
Picture; taken by Indian Satellite INSAT-ID

Whites are Clouds



(Samarjeet Kar, Science/Desh, 1991)

Figure 10



CYCLONE TRACE OF 29th APRIL 1991
N
85°E
90°E
95°E
25°N
20°N
15°N
10°N
30 4 91
DHAKA
KHULNA
CALCUTTA
CHITTAGONG
COX'S BAZAR
BALESORE
CATTAK
29.4.91 (2 p.m.)
AKYAB
29.4.91 (noon)
29.4.91 (7 am)
28.4.91
YANGON
27.4.91
26.4.91
PORT BLAIR
25.4.91
24.4.91
23.4.91

Figure 11

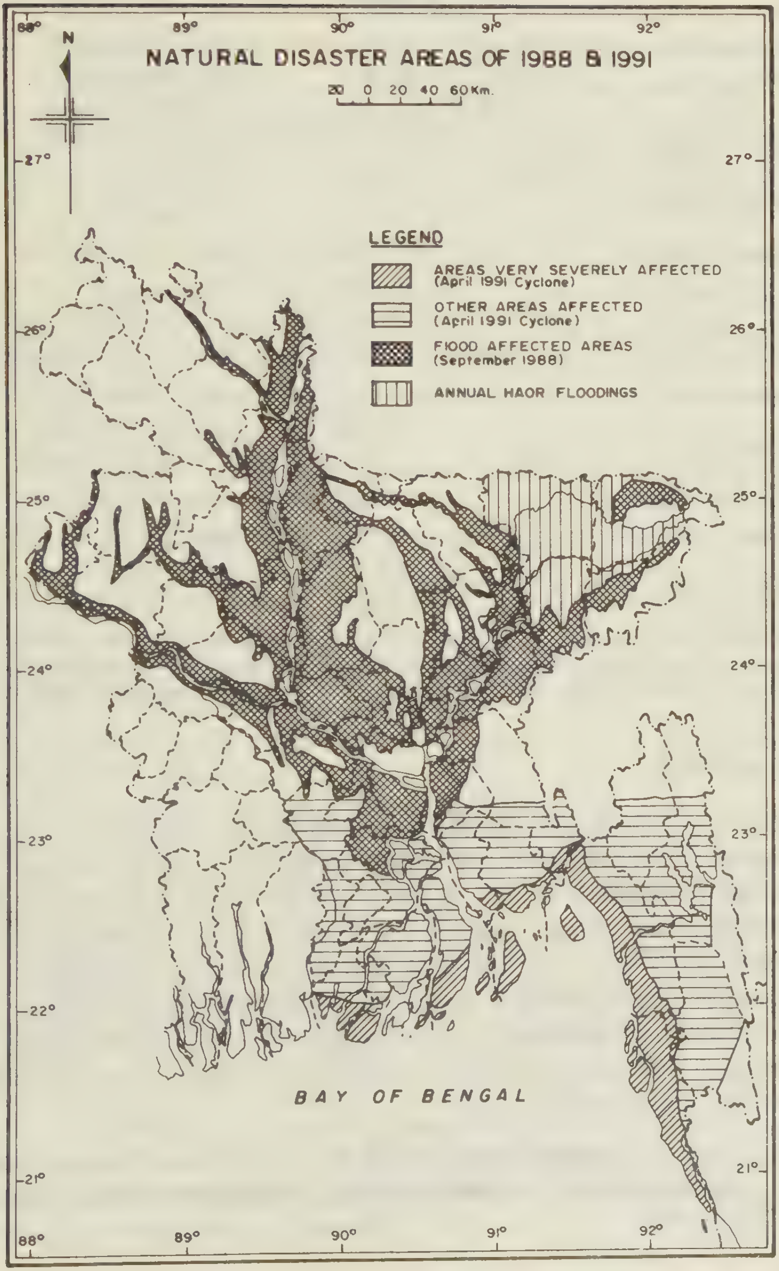

NATURAL DISASTER AREAS OF 1988 & 1991
20 0 20 40 60 Km.
N
LEGEND
AREAS VERY SEVERELY AFFECTED (April 1991 Cyclone)
OTHER AREAS AFFECTED (April 1991 Cyclone)
FLOOD AFFECTED AREAS (September 1988)
ANNUAL HAOR FLOODINGS
BAY OF BENGAL
88°
89°
90°
91°
92°
27°
26°
25°
24°
23°
22°
21°

Table 2

Date		Maximum Wind-speed (Km./hr)	Storm Surge-height (Metre)
30 Oct.	1960	211	4.6 — 6.1
30 May	1961	146	6.1 — 8.8
28 May	1963	203	4.2 — 5.2
31 May	1965	—	6.1 — 7.6
14 Dec.	1965	211	4.6 — 6.1
01 Oct.	1966	146	4.6 — 9.1
07 May	1970	—	3.0 — 4.9
12 Nov.	1970	227	6.1 — 9.1
25 May	1985	154	3.0 — 4.9
29 Nov.	1988	150	3.0 — 4.0
29 April	1991	225	6.0 — 7.5

Source: Choudhury 1987, 1991 and Bangladesh Meteorological Department 1988.

Droughts

Drought is an abnormal condition where there is lack of sufficient water to meet various requirements and support satisfactory plant growth without enough soil moisture. This results from insufficient or no rainfall for an extended period, causing a considerable hydrological (water) imbalance and consequently water shortage, crop damage, stream flow reduction and depletion of ground water and soil moisture. In drought conditions, evaporation and transpiration exceeds precipitation and if it continues for a prolonged period, serious hazards to agricultural production occur. Basically, there are three types of droughts:

- Permanent drought characterises the driest climate having sparse vegetation adapted to aridity and agriculture cannot be practised without irrigation.

- Seasonal drought occurs in places where there are well defined annual rainy and dry seasons, due to abnormal rainfall shortage.
- Unpredictable drought involves an abnormal rainfall failure mostly in humid and sub-humid climates in localized areas.

Sometime the 'dry spell' occurs for a shorter period/duration of abnormally low rainfall.

Droughts are a global phenomena and have occurred throughout human history. The severe droughts of Sahel area of Africa in 1910-1914, 1940-1944, 1972-1975 and 1982-1985 are worthmentioning. The Indian drought 1965-1967 created famine conditions. A prolonged drought (1975-1977) in USA and the serious drought in the western part of USA in 1988 also drastically reduced food grain production.

In Bangladesh, drought of 1979 was one of the severest, though it had occurred in the past also. The deficiency in rainfall i.e. drought conditions mostly occur in Bangladesh, during the pre-monsoon and post-monsoon periods in spatially limited area affecting parts of Bangladesh. A study by (Chowdhury and Hussain 1983) showed that drought conditions never affected the entire country and its total population in any drought year from 1949 to 1979. The percentage of the drought affected areas was in 1951 (31.63 per cent of the whole country) 1957 (46.54 per cent), 1958 (37.47 per cent), 1961 (22.39 per cent), 1966 (18.42 per cent), 1972 (42.48 per cent) and 1979 (42.04 per cent).

The severe impact of drought on agricultural production and development strategies in drought-prone areas of Bangladesh have been dealt in-depth by (Brammer 1985 a,b). The salient features of these strategies are to consider environmental variability, climatic variability, agro-ecological zones of Bangladesh and existing cropping patterns and practices, soil problems, other agricultural factors, constraints etc. A thorough study of supplementary moisture sources like capillary rise, flood water, tidal flooding, seepage, irrigation etc. and their optimum uses in appropriate locations has been suggested. In dry weather/drought conditions, possible crops in localized areas have also been mentioned. For further details of drought studies, references are made and can be found in (Encyclopedia Britannica 1980, Khan 1985, Choudhury 1989 and Karmakar 1989). Figure 12 shows drought conditions in Matuail near Dhaka City.

Figure 12

DROUGHT CONDITION IN MATUAIL NEAR DHAKA CITY

(The Bangladesh Observer, April 21, 1991)

Abnormal Rainfall, Hailstorms and Lightning

The mean annual rainfall in Bangladesh varies from about 1400 mm. in the western part of the country to almost 5000 mm. in the north-east region. There are wide seasonal fluctuations with about 90 per cent of the rainfall occurring in the four months period of the monsoon (June-Sept.). Monsoon depression formed in the Bay of Bengal moves landward and causes widespread rainfall throughout the country. Depending on the formation, structure, intensity and frequency of the monsoon depression, the total rainfall during the monsoon period will be decided. In spite of an overall abundance of rainfall during monsoon, serious droughts do occur. Sometimes inadequate rainfall occurs during the monsoon and minimum rainfall during the dry season (Oct.-March). A number of constraints are inherent in the monsoon rainfall and climatic pattern. In addition, uncertainty in pre-monsoon showers and hailstorms, lighting etc. causes tremendous impact on agricultural production (Khan 1985).

The month-to-month and year-to-year variations in the atmospheric parameters like rainfall, temperature, humidity etc. cause substantial variations in crop yields. Studies of 10-day average behaviour of atmospheric parameters and crop phenology and yields on systematic basis on localized scale will depict climatic patterns and its dependence on agricultural production. Other factors needing study are:

- Timing of on-set and withdrawal of monsoon in a particular year and its impact on agricultural production.
- Number of nor'westers and tornadoes during pre-monsoon periods and its effect in the crop phenology, particularly, in the *aus* crop growing seasons.
- Adjustment of cropping pattern based on environmental and climatic variability and agro-ecological zoning approach.

The pattern of life and cultivation practices have traditionally been adapted to climatic characteristics and seasonal variabilities in Bangladesh.

Nor'westers and Tornadoes

Bangladesh is a part of the humid tropics and seasons in Bangladesh may be broadly divided into three:

- Winter (Nov.-Feb.): Mild and mainly dry, little or no rainfall, receding humidity, bright sunshine etc.

- Summer (March-May): One fifth of the total annual rainfall occurs during this period with frequent visits by nor'westers and tornadoes, maximum temperature is in April, low humidity and high evaporation.
- Rainy season or monsoon months (Jun-Oct.): Warm, rainy, humid and low solar radiation.

Mean annual temperature is about 25-26°C (78°F). The highest temperature is approximately 43°C (110°F). Rainfall distribution varies from region to region. Mean annual rainfall is 2540 mm. (100 inches). The lowest rainfall occurs in the north, and south-west. The highest rainfall of about 5080 mm. (200 inches) occurs in the north-eastern border region along the Assam Hills of India. Everywhere in the country about 90 per cent of annual rainfall occurs between mid-April and early October. Rains are associated with tropical cyclones. Due to nor'westers and thunderstorms there are short pre-monsoon showers during March and May (Khan 1985).

The two transitional periods between south-west and north-east monsoons over the Indian Sub-continent are characterised by local severe storms. The transitional periods are usually known as pre-monsoon (March-May) and post-monsoon (Oct.-Nov). Of these two, it is the pre-monsoon period when most of the abnormal rainfall/ drought conditions, as well as local severe storms popularly known as nor'westers, (*Kalbaishakhi*) occur over different parts of Bangladesh at frequent intervals. Tornadoes are generally associated with severe nor'westers. The tornado forms within nor'westers and moves along the direction of the squall of the mother storm i.e. from west to east or north-west to south-east. The life of a tornado is very short. A tornado is formed because of interactions of two air masses of different types:

- Moist and warm air.
- Dry and cold air resulting in extreme form of instability.

Frequency of nor'westers usually reaches a maximum in April, whereas it is comparatively little in May and minimum in March. Nor'westers and tornadoes are more frequent in the afternoon. Nor'westers may occur in late February due to early withdrawal of winter from Bangladesh, Bihar, West Bengal, Assam and adjoining areas, whereas, the occasional occurrence of nor'westers in early June is due to delay in the onset of south-west monsoon over the region (Karmakar 1989).

Wind-sheeds in nor'westers usually do not exceed 113-130 km./hr. (70-80 miles/hr.) though often their sheeds exceed 162 km./hr. (100 miles/hr.) or even several hundred km./miles per hour when they are usually termed tornadoes. Nor'westers bring much needed pre-monsoon rain. They also cause a lot of havoc and destruction. Nor'westers which are formed suddenly which are extremely localized in nature and are of brief duration. As such, it is very difficult to locate them and to forecast their occurrences with the present state-of-the-art technique. However, high resolution satellite pictures, suitable radars and a network of densely meteorological observatories will be useful for the prediction/warning of nor'westers/tornadoes (Choudhury 1979).

Some of the devastating nor'westers and tornadoes which have occurred over different parts of Bangladesh in recent years are given below:

14 April 1969	—	Demra (Dhaka)
17 April 1973	—	Manikganj (Dhaka)
10 April 1974	—	Faridpur
11 April 1974	—	Bogra
09 May 1976	—	Narayanganj
01 April 1977	—	Faridpur
26 April 1989	—	Saturia (Manikganj)

(Karmakar 1989 and local newspapers).

Earthquakes

Bangladesh has been divided into four seismic zones:

- Zone I (the most active zone) : The north and north-eastern parts including the towns of Sylhet, Mymensingh and Rangpur.
- Zone II (moderate zone) : Dinajpur, Bogra, Tangail, Dhaka, Comilla and Chittagong Hill Tracts.
- Zone III (minor zone) : Rajshahi, Pabna, Faridpur, Noakhali, Chittagong and Cox's Bazar.
- Zone IV (very weak zone) : The south-western parts of Bangladesh including Jessore, Khulna, Barisal and Patuakhali.

The north-eastern part of Bangladesh is in the most active seismic zone and has experienced earthquakes of moderate/high intensity. The great earthquake of 1897 which had its epicentre in the Shillong Plateau of India caused widespread damages. Two other major earthquakes—the Bengal earthquake of 1885 and Srimangal earthquake of 1918 caused severe damages on limited areas surrounding their epicentres. In addition, major earthquakes occurred in Bangladesh and surrounding areas in the years 1833, 1897, 1906, 1918, 1923, 1926, 1927, 1930, 1934, 1939, 1941, 1943, 1947, 1950, 1951, 1954, 1957, 1962, 1965 and 1988 (Karmakar 1989). Earthquakes with magnitudes between 7.0 and 8.7 on the Richter scale have been experienced, but they are rare events (Brammer and Khan 1990).

Impact of Natural Disasters on Bangladesh

Bangladesh being a disaster-prone country is subject to colossal damages to life and property almost every year due to natural disasters and climatic hazards. This has tremendous impact on the overall economy of the country. All the national planning efforts for development activities are disrupted by these calamities by damaging infrastructural facilities, physical assets and other properties. In addition, the human suffering is beyond description.

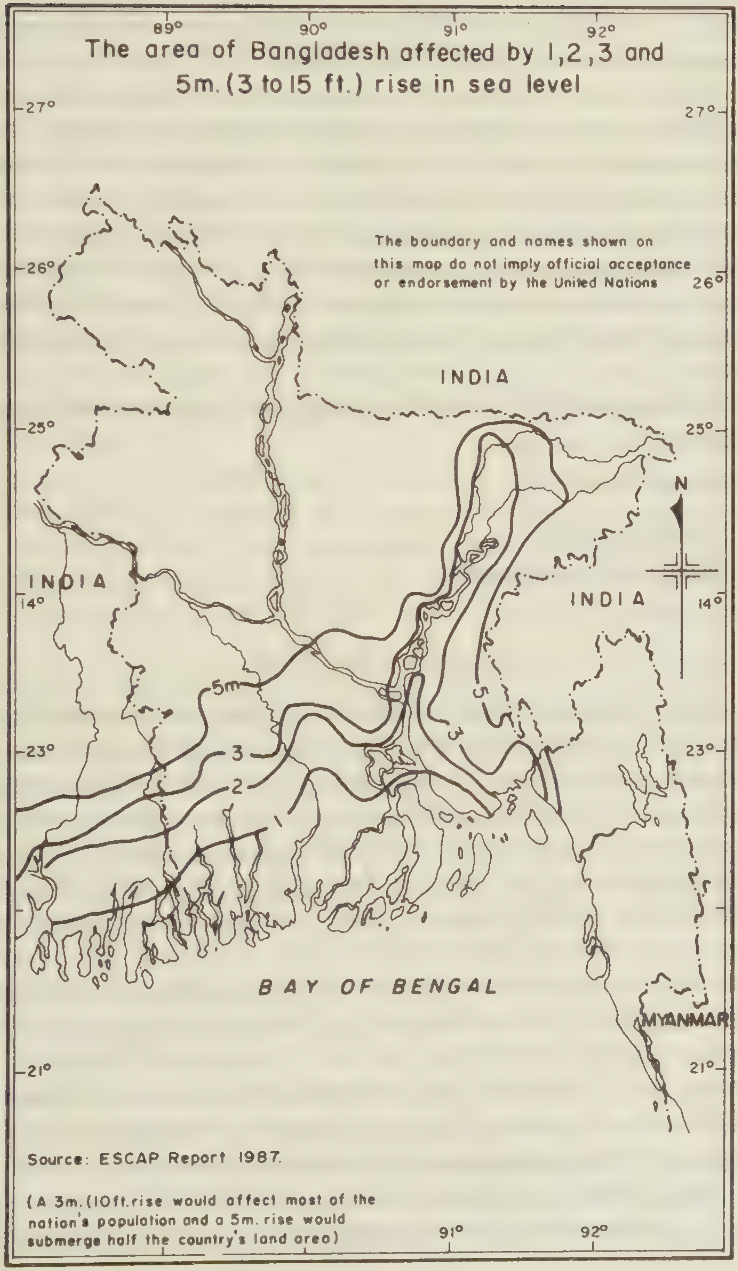
It is estimated that in the order of US$25 billion worth of resources of Bangladesh have been destroyed by natural calamities from 1947 to 1991 (Rahman 1989, Planning Commission Report 1991, BCAS 1991 and Task Force Reports 1991).

The present burning issues of greenhouse effect and depletion of ozone layer causing global warming will definitely aggravate the situation further in the future. Possible sea level rise will inundate the low-lying areas of the country by displacing human habitat and agricultural and forest land. The scenario for 1 m., 2 m., 3 m. and 5 m. sea level rise are shown in Figure 13 (Ali, 1989 and WHOI-1986).

Methods and Techniques of Investigating Natural Disasters Including Prediction, Warning Information Dissemination System and Damage Assessment

The science of meteorology deals with uncontrolled atmospheric sciences with a number of variables and unpredictable parameters changing with

Figure 13



Couresy John Milliman and Frank Gobale

space and time. This has developed tremendously during the last hundred years or so. Even the advanced countries in the world established their meteorological services in the middle of the nineteenth century, in the 1860s and 1870s. During this period, the exchange of meteorological data started. World Wars I and II boosted the technology of weather observation and weather forecasting. The advent of space age in the mid-1950s forwarded understanding of the complex atmospheric system. As such, the weather forecasting and disaster warning systems have been improved to some extent. High resolution aerial survey and satellite data and numerical weather forecasting using computer techniques have further improved the prediction, warning, information dissemination and damage assessment system, all over the world.

There are mainly five divisions of labour in the preparation of a weather forecast/disaster warning.

- Observations.
- Communications.
- Display and manipulations.
- Analysis.
- Prognosis i.e. the preparation of the forecast.

All the divisions of labour are equally important and interdependent on each other. For better and accurate forecasting, each division will have to be developed equally with more consistency and accuracy. Failure of one division will affect the ultimate forecasting and warning. As such, modernization and improvements in each division will have to be effected side by side.

Observation data are collected through field observatories/ stations, merchant ships, aircrafts, radar and satellite systems. The atmospheric parameters like temperature, pressure, humidity, precipitation etc. are required to be known as accurately as possible. When the synoptic data are combined with radar imagery and satellite pictures, valuable information are derived which are useful for accurate and consistent forecasting and disaster warning. Thus the space meteorology will provide information on a synoptic scale on real-time basis and shall always supplement the traditional synoptic meteorology. Both techniques should advance simultaneously.

Though significant improvement has been made in the forecasting/ warning systems during the past three decades, even today with all the available

advanced and sophisticated space technology, elaborate computer processing systems, better communication facilities etc. the accuracy and precision in forecasting/warning still needs further refined perfection because of variable and unpredictable behaviour of nature and the universe.

In Bangladesh, the Space Research and Remote Sensing Organization (SPARRSO) deals with space meteorology and provides information/ data on agro-climatic and disaster-monitoring, map-making as well as resource inventory and surveys. The conventional data collected by Bangladesh Meteorological Department (BMD) and Bangladesh Water Development Board (BWDB) are compiled and analysed by the respective agencies. They use the satellite/space data for further refinement in disaster warnings, like cyclones, floods, droughts etc. The interactions and flow-sheets for storm warning by BMD and flood forecasting by BWDB in Bangladesh are shown in Figures. 14 and 15.

A synoptic overview of damages of an area of inundation/affected could be obtained by satellite technique in delayed mode. The real-time damage assessment at larger scale needs reconnaissance aerial survey by aircrafts filled with necessary camera/scanner etc. In Bangladesh, survey aircrafts are not yet available but attempts are being made to procure one in the near future.

There has been tremendous progress in the technology and the resolution (fineness of the system) during the last three decades. The meteorological satellites in the 1960s have the resolution of 1000 m., the resource satellites like Landsat in 1970s have the resolution of 100 m. and the SPOT in 1980s has the resolution of 10 m. There is progress/advancement of the order of magnitude in almost every decade. In the future, further refinement and better resolution is expected, enhancing the capability of disaster warning and damage assessment both globally, regionally and nationally.

An International Decade for Natural Disasters Reduction

In resolution 42/169 of 11 December 1987, the United Nations General Assembly with delegates from 93 countries decided to designate the 1990s as an International Decade for Natural Disaster Reduction (IDNDR). This was acceptance of the idea of launching an international Decade proposed by the President of the US National Academy of Sciences in 1984. The major

Figure 14

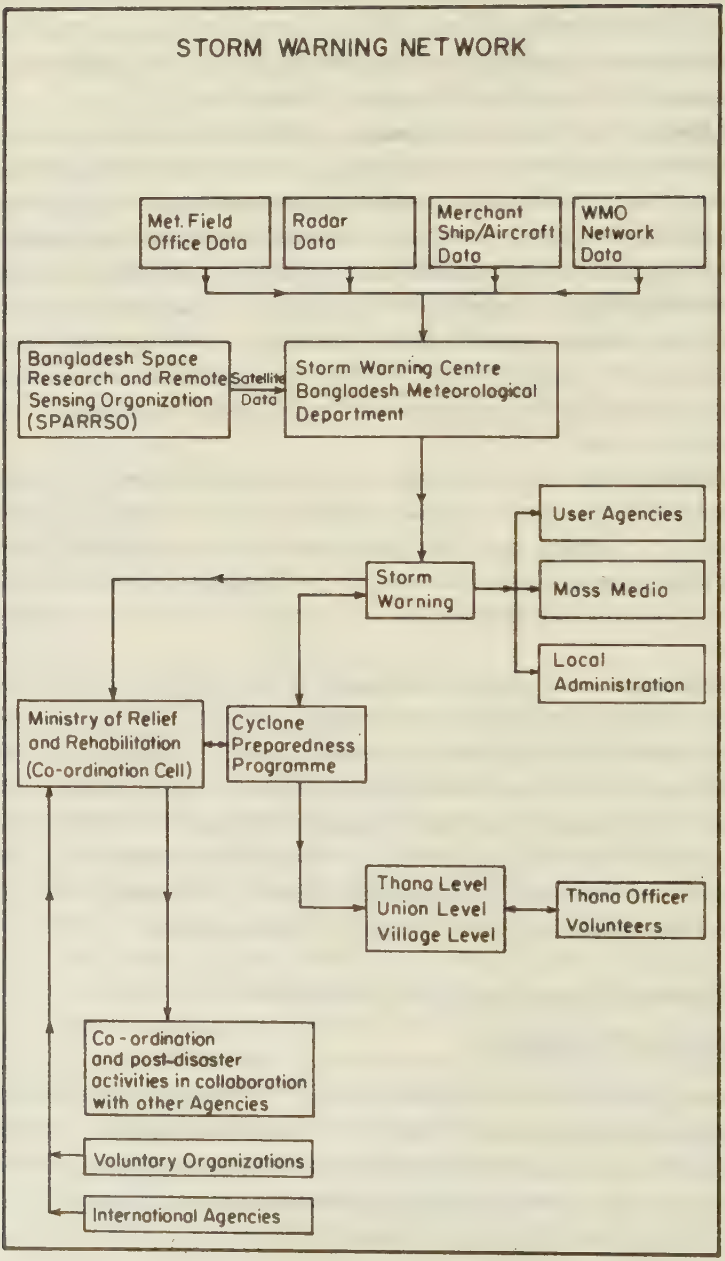
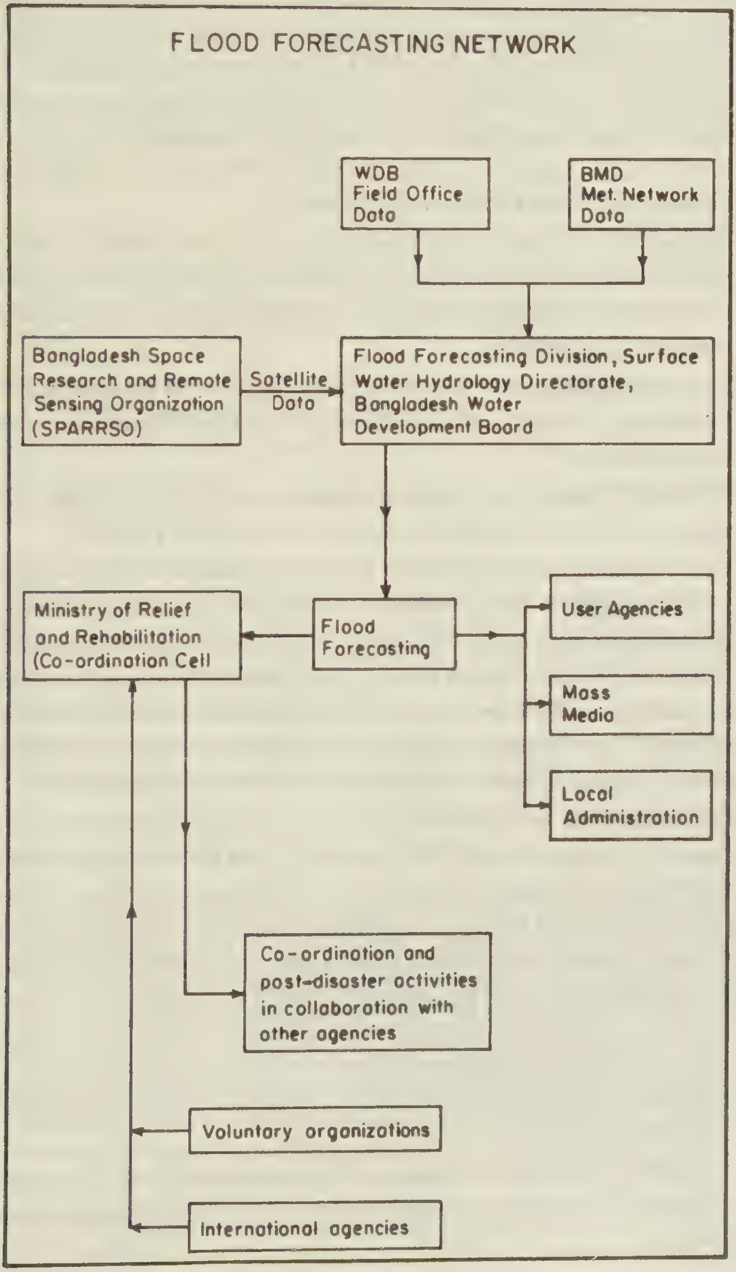

STORM WARNING NETWORK
Met. Field Office Data
Radar Data
Merchant Ship/Aircraft Data
WMO Network Data
Bangladesh Space Research and Remote Sensing Organization (SPARRSO)
Satellite Data
Storm Warning Centre Bangladesh Meteorological Department
User Agencies
Storm Warning
Mass Media
Local Administration
Ministry of Relief and Rehabilitation (Co-ordination Cell)
Cyclone Preparedness Programme
Thana Level Union Level Village Level
Thana Officer Volunteers
Co-ordination and post-disaster activities in collaboration with other Agencies
Voluntary Organizations
International Agencies

Figure 15


FLOOD FORECASTING NETWORK
WDB Field Office Data
BMD Met. Network Data
Bangladesh Space Research and Remote Sensing Organization (SPARRSO)
Satellite Data
Flood Forecasting Division, Surface Water Hydrology Directorate, Bangladesh Water Development Board
Ministry of Relief and Rehabilitation (Co-ordination Cell
Flood Forecasting
User Agencies
Mass Media
Local Administration
Co-ordination and post-disaster activities in collaboration with other agencies
Voluntary organizations
International agencies

objective of IDNDR is to promote during the 1990s, a concerted international effort to reduce the loss of life, property damage, social and economic disruption caused throughout the world by the violent and catastrophic forces of nature i.e. natural disasters such as earthquakes, windstorms (cyclones, hurricanes, tornadoes, typhoons); *tsunami f*loods, landslides, volcanic eruptions, wildfires and other calamities of natural origin, such as grasshopper and locust infestations, and that its goals are:

- To improve the capacity of each country to mitigate the effects of natural disasters expeditiously and effectively, paying special attention to assisting developing countries in the establishment, when needed, of early warning systems.
- To devise appropriate guidelines and strategies for applying existing knowledge, taking into account the cultural and economic diversity among nations.
- To foster scientific and engineering endeavours aimed at closing critical gaps in knowledge, in order to reduce loss of life and property.
- To disseminate existing and new information related to measures for the assessment, prediction, prevention and mitigation of natural disasters.
- To develop measures for the assessment, prediction, prevention and mitigation of natural disasters through programmes of technical assistance and technology transfer, demonstration projects, education and training tailored to specific hazards and locations and to evaluate the effectiveness of those programmes (UNDTCH/UNCRD Publication 1988).

With the advent of science and technology, human civilization has progressed tremendously and these advances have given an opportunity to provide better warning and protection for people and their property in the areas at risk. There are many ways in which modern science and technology can be used to reduce the risks and losses caused by natural disasters such as floods, cyclones, storm surges, droughts, volcanic eruptions, earthquakes, landslides and other violent phenomena. The preventive and protective measures of general nature are given below but these may have to be modified and adapted as per need and requirement of a particular disaster/country/region as the case may be:

- *Preventive action on the causes of the phenomenon itself*: For example, soil conservation and engineering works for flood prevention and control.

- *Hazard assessment and warning:* This involves identification of the areas exposed to various hazards, the quantification of the hazards (i.e. the probability of occurrence of potentially destructive phenomena) and the establishment of appropriate systems for monitoring, forecasting and warning of impending events.
- *Short-term protective measures and preparedness*: In response to imminent warnings, much can be done to reduce the vulnerability of people and property by adopting temporary protective measures, by mobilizing medical teams and fire-fighting services or in extreme cases, by evacuating the population from the endangered areas.
- *Long-term protective measures*: In the face of known hazards, the attendant risks and eventual losses can be reduced by adopting permanent protective measures such as, earthquake-resistant design and development and construction of essential services, industrial plants, urban lifelines, etc.
- *Land-use and risk management*: Risks and losses can often be reduced significantly by the appropriate choice of less hazardous sites for new human settlements and industrial projects. Agricultural methods can be adopted to minimize the risks attendant on flooding or soil instability.
- *Public information and education*: None of these preventive or protective measures will be fully effective without the informed participation of the whole community. Both the teaching profession and the news media can do much to improve public understanding of natural hazards and possible measures to protect them.

All these kinds of action must be based on sound knowledge of the nature of the potentially destructive phenomena and of the techniques of prevention, protection and emergency response. Scientists and engineers have, therefore, an important role to play, not only in conducting research but in communicating their knowledge clearly and precisely to public safety officials, urban planners and architects. Indeed, much of the international efforts during the Decade will be dedicated to promoting better communication and understanding between the producers and users of scientific and technical information.

The Decade is an international Decade, and its programme will be one of concerted action by many people and institutions in countries throughout

the world. However, prevention, protection and preparedness against natural disasters require action on the spot, that is to say, in the countries and at the places where disasters may occur. Such action can only be planned and organized at the national or local level. The key to success will, therefore, be the creation, in each country liable to natural disasters, of national groups or committees who will decide what action can be taken to achieve the objectives and goals of the Decade. In addition, a concerted international effort will be essential. Natural phenomena not respecting national frontiers, many of the scientific and technical studies on which action must be based will be of necessity, regional or even global in their scope.

The Decade will provide a framework into which a wide variety of projects and activities may be introduced on the initiative of national or international agencies, institutions or groups. However, in order that these projects and activities constitute a coherent and concerted attack on the problem of natural disasters and that a high level of professional and technical competence in their planning and execution be maintained, the establishment of appropriate mechanisms for their planning and coordination is foreseen.

An international committee composed of leading experts in disaster prevention and preparedness will, therefore, be set up to provide high level scientific and technical guidance. The specialized agencies of the United Nations and many international non-governmental organizations will bring their experience and expertise to bear on the problem. If, as it is expected, national organizations for the Decade are set up in each of the disaster-prone countries, there is hope that by the end of the Decade, mankind will have gone far towards learning to live with natural hazards and not simply to suffer from their violence. (UNDRO documents and UNDRO News 1988).

Bangladesh also decided to observe the 1990s as the "Decade of Environment" and 1990 as the "Year of Environment". An action plan and programme is to be prepared in consultation with national and international experts in the field.

Recommendations for Remedial/Mitigation Measures

The diversity, complexity and dynamics of the natural disasters and environmental hazards of Bangladesh need an elaborate system of warning, well ahead of time. The complexity of the problems makes it very difficult

to predict the impending danger and the socio-economic conditions and logistic support facilities, making it more difficult to take appropriate actions. Within the framework of the given conditions, the following recommendations are made:

- Believing in the philosophy of "Living with natural disasters" appropriate system of warning, forecasting and preparedness programme should be developed in the country.
- The reliability and accuracy of various natural disasters related data in the fields of geo-agro-hydro-meteorological, topographical and environmental aspects should be ensured at the various stages of operations in natural disaster management.
- Conception and participation of the local people should be sought in the disaster management process through strengthening the institutional capability of the concerned agencies and developing interactions between the various target groups including decision-makers, planners, administrators and people at the grass-root level.
- Technical capability and sophisticated methodology should be developed in the management of natural disasters through appropriate human resources development, know-how and technology transfer and information-data-base system.
- Close interfaces and linkages between different disaster related institutions and much more collaboration should be streamlined for disaster management.
- Disaster management systems, both formal and informal should be institutionalized through appropriate action-oriented programmes like erecting shelters, embankments, afforestation, income-generating activities etc. on site-specific approaches.
- Continuous monitoring and research in the disaster management methodology and procedural technology on subject-related natural disasters like floods, cyclones, droughts etc. should be developed in the country.
- International collaboration, globally and regionally, should be developed in disaster management techniques through financial assistance, know-how and technology transfer of related issues.

- Instruction manuals and emergency guidelines for various natural disasters should be adopted within a framework of a disaster Management Policy having interactions with other national policies promulgated in the country.
- Operation and maintenance and follow-up actions can be undertaken through direct involvement of the beneficiaries and local people.
- Mandatory Environmental Impact Assessment of all development projects, particularly Flood Action Plan (FAP) and Flood Control, Drainage and Irrigation (FCDI) Projects should be undertaken.
- Formation of international network for exchange of information/data/ expertise on disaster warning and management should be made.
- Mass awareness, public information methodology and mass-media activities should be strengthened, particularly, for disaster management, survival techniques and time-space-based action-oriented approaches etc.

Conclusion

The present paper has dealt with various aspects of natural disasters like floods, droughts, cyclones, storm-surges etc. followed by some recommendations with a view to undertaking appropriate steps through both structural and non-structural means without causing environmental degradation and ecological imbalance. At every stage of design, implementation and monitoring of projects, proper care is needed to ensure these aspects.

Natural disasters are not limited to any one country but its impact on a particular region, depends on the type of disaster occurring. As such, a collaborative approach to mitigate and to handle disasters should be undertaken on a regional and global bases. It is felt that Bangladesh should take active part with the world community in observing the International Decade (1990s) for Natural Disasters Reduction (IDNDR). In collaboration, an appropriate and integrated approach to disaster management should be developed so that loss of life and property is minimized and socio-economic improvements in the quality of life are achieved.

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CHAPTER EIGHT

FLOODS, PEOPLE AND THE ENVIRONMENT REFLECTIONS ON RECENT FLOOD PROTECTION MEASURES IN BANGLADESH*

Shapan Adnan

The Findings

The following pages contain the preliminary conclusions of an *ongoing* process of monitoring and evaluating the social, institutional and environmental aspects of flood protection programmes in Bangladesh. Hence, the findings presented here are by no means final and definitive, but rather provide a *provisional assessment* of the recent state of affairs, which may well change over time. However, to the extent that the present analysis is valid, it does tell us something about the way things have been happening so far. Furthermore, it also throws up certain ideas about what might happen in the future, in the way of probable trends. Both these considerations have corresponding policy implications, as taken up below.

Objectives and Contents

The discussion below looks at the existing flood protection programmes of Bangladesh, including the Flood Action Plan, and moves towards an analytical treatment of certain critical issues. Of particular significance are

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questions about the real beneficiaries of flood control and drainage (FCD) structures, as well as their impact on the conservation of 'common property resources.' These, in turn, are related to issues of the maintenance of national interests, which are further elaborated below.

The treatment focuses upon assessment of short run trends in flooding during 1990, and the various institutions which were charged to cope with flood-related problems. Considered next are the *effects* of flooding, as well as the actual performance of the presently existing flood control and drainage structures. The discussion subsumes social, economic, demographic and environmental consequences, with special attention being given to the impact on women and children. The analysis then moves on towards identifying the *causal factors* underlying these outcomes. The discussion covers both short and long run scenarios, taking account of technical, institutional and structural constraints, as well as the misuse of resources intended for flood protection. Critical questions about public information and people's responses to these problems are taken up next. In conclusion, possible future trends are tentatively put forward as *hypotheses*, and a range of policy implications are identified on the basis of the preceding analysis. It is hoped that these will provide alternative options for consideration by decision-makers in the Government of Bangladesh, as well as other concerned agencies including donor organizations and NGOs.

Most of the sources used for this study are *publicly available* documents such as academic papers, newspapers, government publications, and other agency reports.[1] It is important to note that the bulk of the evidence used to reach these conclusions comes from the period up to October, 1990. Indeed, much of the information on what happened during the course of 1990 did not become available until after the end of that year, following the downfall of the Ershad regime.[2]

Complexities of Bangladesh's Flood Problem

The flood problems of Bangladesh are complex and multifaceted, rather than being just 'one thing.' The constituent elements include: (a) rise in water levels, (b) waterlogging, and (c) river erosion. These three elements, while being interrelated, do *not* necessarily go together, and could well arise from quite distinct causal factors. Furthermore, most of the catchment areas of the Ganges-Brahmaputra-Meghna river systems lie outside the territorial limits

of Bangladesh. The problem thus has international dimensions which are inherent in it.

Genesis of the Flood Action Plan

Following the disastrous floods of 1987 and 1988, some of the G-7 countries, as well as major international organizations like the UNDP and the World Bank, began to express interest in the matter. In institutional terms, Bangladesh's flood problem became internationalized as these publicly expressed concerns became translated into a number of studies and planning documents commissioned by the UNDP/GOB, France, USAID, Japan, etc.[3] In July, 1989, the G-7 summit in Paris issued a communique which endorsed the World Bank's role as coordinator of a massive plan to control the floods and their damages in Bangladesh.[4] The final draft of the *Action Plan for Flood Control* was presented and formally approved in a meeting in London in December, 1989, which was attended by the representatives of the concerned governments and donor agencies.[5]

It is important to recall that the FAP (Flood Action Plan), as it became known, was never ratified by a legitimate parliament consisting of *bona fide* elected representatives of the people of Bangladesh. In fact, the very genesis of the Action Plan, hastily propelled by an autocratic regime, is shrouded in rather complex circumstances. At least some of these reflected considerations of enlightened self-interest on the part of the agencies involved, garbed under the humanitarian concern for flood-affected people. The Plan document itself was the end-product of a series of exercises involving local and international consultants, including firms, not all of which were perhaps devoid of purely commercial, and other self-seeking, interests. In fact, it is interesting to find that certain *overlapping* sets of individuals and organizations have continued to remain involved all through the stages of plan formulation, implementation, supervision, monitoring and evaluation.

It is a moot question as to whether such activities have been in the best interests of the country—since public goods and services on this scale ought to be *independently* monitored and evaluated by people and institutions *different* from those involved in plan formulation and implementation. Significantly, there was not even any attempt to provide a serious reply to the grave and disturbing criticisms of the Action Plan, made by concerned academics, professionals, and practitioners, both from Bangladesh and abroad.

Intellectual dissent within the country was harshly repressed, and individual professionals and leaders of the scientific community were victimized in certain instances. The most outrageous instance of this was the premature retirement of Dr. M.M. Rahman, the then Executive Vice-Chairman of the Bangladesh Agricultural Research Council (BARC), on a flimsy technical pretext. He had chaired a discussion at BARC on 30th November 1989 of a group of Bangladeshi professionals. The meeting had resulted in an intellectual critique of the Action Plan, which was subsequently published by BARC with an outspoken and courageous foreword by Dr. Rahman.[6]

This state of affairs did not change until after the fall of the Ershad regime at the end of 1990. The Planning Adviser of the interim government appointed an honorary Task Force composed of Bangladeshi professionals to provide a quick critical review of the FAP and its performance to date, as well as a set of recommendations for the benefit of future policy-makers. This report by the Task Force was submitted to the Acting President of Bangladesh, as well as the leaders of all major political parties of the country, in February, 1991.[7]

Contents of the Flood Action Plan

The plan document itself betrays inner inconsistencies, as well as explicit and implicit predispositions in favour of particular 'solutions' to the flood 'problem.' This is all the more striking since the "Action Plan for Flood Control" *pretends to be a scientific document* and provides the required lip-service to various concerns related to the public good. It is significant that the so-called 'Eleven Guiding Principles,' initially defined with the help of hired commercial firms, and subsequently authorized by the autocratic Ershad regime, have never been *intellectually* defended. This has been the case despite the fact that some of these 'guiding principles' contained glaring prejudgements about the outcomes of supposedly investigative studies of the Action Plan. This was nothing less than *making a mockery of the scientific method,* since the results of investigative exercises can hardly be presupposed.

Equally, environmental concerns are parroted as required, but in practice quite brusquely treated by the plan document. Latter-day attempts to 'make amends by incorporating environmental safeguards' in all relevant studies

fail to be convincing because the essential strategy of constructing compartments based on polders and embankments is *not made contingent* on the findings and outcomes of the vital investigative studies. The only concession made by the modified 'Terms of References' of various FAP components is to display greater concern about 'mitigating measures', so as to 'compensate' for possible negative impacts of the proposed FCD physical constructions.[8]

The Institutional Matrix of Flood Control Programmes

The 'institutional matrix' dealing with flood-related problems and projects included both national and international agencies. These were concerned with the FAP, as well as other flood protection programmes and projects. Some of these were 'ongoing' projects being implemented by different 'Line Ministries.' However, the Government of Bangladesh also set up agencies and institutional entities for dealing specially with the FAP, such as the Flood Plan Coordination Organization (FPCO), the National Flood Council (NFC), the Implementation Committee (IC) and the Technical Committee (TC). Supportive roles were played by more permanent institutions like the Ministry of Flood Control itself, the BWDB, the MPO and the RRI. In effect, a whole set of agencies held authority over rather complicated procedures of approving the various components of the Action Plan, as well as dealing with other parallel flood protection programmes. The World Bank, in particular, occupied a key position which involved coordination of the activities of the various donor agencies, as well as the *de facto* supervision of the FPCO and other Bangladeshi implementing agencies.

It was predictable that there would be areas of conflict between the concerned institutions and agencies about their respective areas of work. At stake was the 'institutional division of labour and authority,' as well as the consequential distribution of the substantial resources earmarked for the FAP. In fact, by the end of 1990, it appeared that the BWDB was perhaps making a bid to take over as much of the responsibility for implementing FAP components as possible, in the capacity of the *executing agency*.[9] On the other hand, the FPCO proposed to expand itself to take on "umbrella responsibility for supervising, coordinating, monitoring and evaluating" the FAP. This proposal, however, entailed problematic 'conflict of interest' roles, since the FPCO would then become empowered to monitor and

evaluate its *own performance* as the supervising and coordinating agency. This was obviously dysfunctional and self-defeating, as far as the objective of evaluation was concerned. Such reservations were indeed strongly expressed by the Task Force on FAP.[10]

Furthermore, the Task Force's report expressed serious concern about the 'Core Panel of Experts' of the FPCO, in respect of appropriate disciplinary balance, the mode of recruitment through commercial consultancy companies, as well as the levels of professional competence in certain cases. Since these international and local consultants on the 'core' panel of experts were vetting the implementation of each and every component of the Action Plan, any lack of objectivity on their part could gravely effect the national interests of Bangladesh.[11]

Overall, the whole set of institutions dealing with flood protection programmes displayed a variety of features, at least some of which were problematic in terms of the disinterested pursuit of the public good. The activities of these agencies displayed certain elements of duplication and unproductive organizational rivalries. *There was lack of coherence and coordination among the programmes undertaken by both national and international agencies.*

Progress of the Action Plan and Related Programmes

Given this institutional division of functions, as well as sheer bureaucratic inertia, cumulative delays could be expected in the paperwork concerned with the approval of FAP components by the Government and donor agencies.[12] It was thus hardly surprising that, by December, 1990, the PCP (Project Concept Papers) and TAPP (Technical Assistance Project Proforma) of only 14 of all the FAP Components had been approved by the Government.

National Trends in Flooding

Flooding in 1990 was of significantly lesser magnitude compared to those in 1987 and 1988. The country-wide pattern is shown in a consolidated form in Figure 1 below. During the months June-October, the largest tracts of continuous flooding were located on the right and left banks of the Brahmaputra. After the rising of flood levels during June-July, there was a

recession of water from the basin of the Brahmaputra-Jamuna despite occasional increases. The Ganges-Padma and the Meghna basins showed fluctuations in water levels during the period from August-October. Significantly, the 'peak flows' of these major river systems did *not* coincide in 1990—unlike 1988, when catastrophic flooding had ensued. Another significant pattern was that of *increased* intensity of bank erosion associated with the *recession* of water levels.

Much of the flood-water flowing downstream from the northern regions of the country gave rise to flooding in its southern tracts. In many cases, such flooding consisted essentially of *waterlogging*, caused by faulty drainage systems. For example, the gravity flow of flood-water was impeded by silted-up channels and distributaries. Furthermore, ill-conceived FCD/I[13] structures, including polders with non-functioning water control mechanisms such as *Beel* Dakatia, provided disturbing examples of *man-made waterlogging* and *ecological disasters*.

A typologically distinct phenomena consisted of 'flash floods' of great intensity, reported from the hilly border areas of Greater Chittagong, Chittagong Hill Tracts, Sylhet and Mymensingh. Such rapid downrush of water occurred several times during the year. While the impact of these flash floods were intense, they were also of very short duration—not lasting more than a few days at a time.

During these months, reports came in virtually every day about the breaching of embankments and the failure of other water control structures. The construction of most of these FCD/I structures antedated the genesis of the FAP. However, these recurrent failures suggested that such outcomes were systematic rather than random. Furthermore, the evidence did little to substantiate some of the rather heroic assumptions made by the Action Plan regarding the resilience and durability of embankments, polders and compartments against the massive forces pitted against them by the mighty river systems flowing through Bangladesh. Indeed, the historical track record, as noted by the plan document itself,[14] did not provide reasons for putting much faith in the *viability* of the strategy underlying the 'compartment-based' approach advocated by FAP.

Furthermore, there were certain *long* term processes of a structural nature which were found to be aggravating the flood and drainage situation in Bangladesh. These included continuing *siltation* of certain rivers at an alarming rate, and the *rising* of embanked river-beds to levels significantly

higher than the surrounding floodplain. If such processes were to persist with cumulative effects, then the essential *strategy* of the Action Plan, based on construction of massive embankments and compartments could well turn out to be quite *self-defeating in the long run*.

Urban-Industrial Centres

Urban-industrial centres provided special cases of flood-affected zones, because of the concentration of population, vital services, facilities, industrial assets, etc. Many towns of commercial and administrative significance faced severe erosion from river activity, such as Chandpur, Bhairab Bazar, Sirajganj and Munshiganj. Dozens of other townships and trading centres all around the country suffered from waterlogging, resulting from the existence of congested and unplanned drainage systems. Most of these were not exceptional or short-run problems caused by the floods of 1990. Rather, these were symptomatic of the existence of longer term *structural factors* which had prevented adequate measures from being taken against river erosion and internal drainage congestion.

The Dhaka City Flood Protection Project

The FAP's contribution to the flood protection programme for Dhaka city was relatively insignificant compared to the Dhaka Flood Protection Project (DFPP), initiated quite independently earlier. As shown in Figure 2, the flood protection constructions planned for Phase I of DFPP, covering the *western* half of the city's perimeter, had been largely, but *not* fully, completed by the end of 1990. Some of the earth-made embankments and R.C.C. (reinforced concrete) walls displayed serious technical problems, including design faults. Thus, sections of the embankment were found to have collapsed or caved in, almost as soon as they had been constructed. Furthermore, numerous breaches existed in the R.C.C. flood walls along the river banks. These had been purposively made, or left open, to permit the transmission of goods by businessmen, as well as for passages used by ordinary people. Such 'perforated' walls would provide little protection against flood-water coming in from the outside. At the same time, given the present state of these walls, they were likely to aggravate the already serious problem of congestion in the city's drainage system.

Furthermore, certain areas *within* the embankment had become waterlogged after their construction because of the blockage of the drainage channels which had existed before. These facts tended to suggest that proper feasibility studies had *not* been carried out *prior* to executing these FCD works around Dhaka city; nor had project implementation been effectively supervised. Another astounding feature of the city's protective works was that virtually all the industrial units of the Dhaka-Narayanganj-Demra (DND) triangle had been left *outside* the flood walls. This would appear to have *undermined* the very rationale of constructing such flood protection works around Dhaka city—particularly, its industrial suburbs. Also, large chunks of human settlement had been left *outside* the protected zone, the most notable of which was Char Kamrangi—a densely populated area containing slums inhabited by extremely low-income households.

Reportedly, the Ministry of the Environment & Forests had recommended that certain segments of the physical constructions of the DFPP should be held in abeyance until measures for the city's already critical drainage and pollution problems could be integrated with them. Nonetheless, there have been disturbing allegations by the press that *construction works have continued despite such cautionary recommendations from governmental bodies*.[15] If true, this would reflect a propensity for 'rushing into construction' *without waiting* for the completion of environmental impact assessments (EIA) and other prior investigative studies. Practices such as the above would *foreclose* the possibility of the results of these studies being fully evaluated and openly debated *before* critical decisions were taken regarding the construction of such public utilities.

Social, Economic & Demographic Consequences

During 1990, river erosion, as well as flooding and waterlogging, led to massive loss of property, including land and physical infrastructure. Many people became destitute overnight, reflecting the flood-generated problems of landlessness and assetlessness. Damages to communications, education, health and other vital services constituted losses in the sphere of *social* infrastructure. In the submerged and deserted village settlements, the very *security* of people's lives and property became endangered. Looting and robbery by criminals, often moving on mechanized boats, were widely reported from these areas, reflecting the state of the 'law and order' situation.

Even so, flood-affected people were observed to pursue a range of *survival strategies* under such conditions of extreme distress. These included shifts of occupation to forms of self-employment suited to flood conditions, such as fishing. Others attempted out-migration in search of shelter and security to urban and (other) rural areas. In certain severely-flooded areas, the very *structure of relative prices* became transformed, with prices of foodgrains shooting up, and wage rates remaining low, given virtual lack of wage or self-employment. Along with reports of a bumper crop this season, the scenario above appeared to be consistent with Amartya Sen's theory of 'exchange entitlements' regarding the occurrence of famines.[16] In this view, famines occur not so much because of a decline in aggregate food availability, as due to failures in the food distribution systems, based on market and non-market mechanisms.[17]

Impact on Women and Children

To begin with, women's traditional roles in the customary division of labour became much more difficult to perform under flood conditions, e.g., cooking, cleaning, fetching drinking water and undertaking homestead production. Women also tended to come *last in the queue* of distressed people waiting to get relief from aid agencies. Typically, children's *access* to such food and relief *depended* primarily on whether their mothers could get their due shares in the first place. Destitute women and children, without incomes or shelter, had to live under the most acute conditions of *physical and social insecurity*. Younger women, particularly among migrants who had been compelled to move away from their flood-affected homes, were often lured away into prostitution. Older women, on their own, were reduced to utter helplessness, and forced to live on charity.

In the flood-affected areas, children suffered from lack of schooling and medical facilities, resulting in the *underdevelopment*, rather than the *formation*, of human capital. This was particularly true of the tracts which had been waterlogged for years together, such as *Beel* Dakatia. The non-existence, or non-functioning, of *common property resources* like schools, clinics and community service centres did not affect everyone to the same extent. While richer families could afford to move to safer and more secure shelters elsewhere, the women and children of the poor were stuck with very limited options. The same differential applied

to instances of ecological disaster and environmental degradation, as indicated below.

Environmental Consequences

Adverse effects upon the environment of both flooding and faulty flood protection works were in evidence. Some of the more long-term consequences appeared to be virtually *irreversible* in character, with very disturbing implications. For example, destruction of *vegetation cover* was reported from flooded areas, eroded tracts, as well as embanked polders which had been waterlogged for years together. The process constituted a kind of 'deforestation' on homestead land and orchards. Other interrelated consequences of flooding affecting health and the environment included: (a) shortage of fuel for cooking and boiling (for purification); (b) the putrefaction of corpses and carcasses in flood-water due to lack of fuel and dry land; (c) spread of waterborne diseases; and overall, (d) general deterioration of healthy and hygienic living conditions.

Often, a major casualty of the operation of FCD/I structures was the preeminent *common property resource* consisting of open water capture fisheries.[18] On the other hand, submersion of private tanks of the rich by flood-water, and the consequent release of the fish stock, constituted an inadvertent mechanism of *adding* to resources available to all flood-affected people attempting to survive. Indeed, freshwater flooding also played a beneficial environmental role by *flushing* out tracts which had been kept artificially waterlogged and saline by shrimp-growing commercial interests, at the cost of the agricultural land, livestock, trees and vegetation cover of the surrounding areas. However, such common property resources were found to be frequently appropriated by powerful profit-making businessmen, endangering the livelihood and healthy living conditions of the poorer and weaker majority.[19] Infliction of illegal violence by external shrimp-growing interests against the local population were reported in many cases, with little remedial action being taken by the Administration.[20]

The most well-publicized case of a *man-made* ecological disaster was provided by the embanked polders of *Beel* Dakatia which had been waterlogged for the last eight years.[21] Significantly, while more of the rich had been in a position to move away, it was the poor majority which had tended to remain stuck with the consequences. The 'experts' from

international agencies, including the firm IECO,[22] which had sold the idea as a 'solution' to the problems of the locality in the 1960s were no longer there, nearly thirty years later, to face up to the long-term consequences of their 'professional advice and expertise'. Nor did they have to share the living conditions faced by the people who had no option other than to continue to dwell there. There are significant lessons to be learnt from such instances about the role of *short-term* consultancy work, which is apparently intended to solve *long-term* problems.

However, this is *not* to say that *all* FCD/I constructions have proved to be disastrous in environmental and ecological terms. A notable exception is provided by the polders (Nos. 22 and 29) under the Delta Development Project (DDP) in Greater Khulna, within which shrimp-culture and associated saline waterlogging has been resisted so far through popular mobilization, with support from an NGO and certain development agencies. Consequently, the agro-ecological systems have not been undermined, and crop production, vegetation cover and livestock-rearing have been able to persist unhampered, unlike adjacent polders where shrimp-growing has become predominant. Indeed, inhabitants of the surrounding region have expressed their willingness and enthusiasm about getting comparable projects initiated in their own areas (polders).

Disturbingly, however, on 7th November, 1990, there was a violent attack by shrimp-growing business interests on landless groups of Polder No. 22, resulting in one woman being killed and many other people being wounded.[23] A comparable attack, involving conflicts of interest about shrimp-growing, took place on 9th January, 1991, on a group of landless men and women in Jakarhula of Madhukhali (Polder No. 20).[24] Significantly, shrimp-growing is approved of by the government in this area, and aided by the World Bank and an NGO working in collaboration with a commercial firm. It provides a classic instance of public goods, in the form of embanked polders, being utilized for private profit-making activities at the expense of potentially irreversible environmental damages affecting the poor majority.

Institutional Constraints

Damage caused by flooding and faulty FCD/I structures was further aggravated by institutional constraints. Instances were provided by *delays* in

approval of flood protection schemes and in releasing adequate funds to implementing agencies. Another kind of intractable, and rather disagreeable, institutional problem concerned the observed reluctance of the Administration to admit that flood-related problems, involving human suffering, *even existed*. A case in point occurred in Sirajganj, where the district administration went on claiming that 'everything was under control' until the end of September, despite widely reported evidence to the contrary.[25] In the end, it had little choice but to admit that if food and relief did not arrive soon, the consequences might well be disastrous in terms of large-scale starvation and possible famine.

By and large, the Administration tended to *keep its distance* from flood-related problems and popular initiatives to counter them—except possibly when such interventions provided it with favourable publicity in the news media. The agencies of the government entrusted with implementing flood protection programmes, such as the BWDB, often restricted their vision to technocratic solutions alone. In particular, the penchant for *capital-intensive* solutions, based on grants and aid from donors, reflected a deeply embedded *ethos of dependency* in the prevalent 'culture of flood control' in Bangladesh.

Technical and Design Problems

The rate and predictability with which embankments, sluices and other FCD/I structures collapsed, or became inoperative, during the relatively normal floods of 1990 would tend to substantiate press allegations that such water control structures were often technically unsound, inappropriately constructed, and/or inadequately maintained. It was reported that many of these FCD/I structures had *not* been *preceded* by a rigourous feasibility study, as should normally be the case. The consideration that river beds can, and do, rise over the years, requiring corresponding raising of the heights of embankments, and sluices on their banks, appears to have been frequently ignored at the stage of designing such structures.

A critical weakness displayed by many flood protection works was the failure to meet the criterion of 'indivisibility'. Thus, flood-water entering an *incompletely protected* area through 'holes and gaps' often turned it into a veritable 'death trap'. This was because the water could not drain out of the area at the rate it would otherwise have drained out, if such incomplete FCD works had not existed there in the first place. The classic example of this

problem was provided during the floods of 1987 and 1988, when the greatest crop damages were reported to have occurred in the area supposedly protected by the Brahmaputra Right Embankment.[26]

Deficiencies in the construction of the earth-made embankments and R.C.C. flood walls for protecting Dhaka city exhibited similar technical and design faults. For example, there were hundreds of 'holes in the wall', along the Burhiganga river which would potentially allow flood-water to move into Dhaka city from the outside, making the supposed protective barrier act more like a sieve.[27] If that were to be the case, then the *remainder* of the protective works, including earth-made embankments, could well create a kind of 'water trap' by *impeding drainage* and submerging much of the low-lying tracts, estimated to be nearly 60% of the city's area.

Mechanisms of Resource Misappropriation and Misuse

Misappropriation of resources and comparable malpractices were found to be *integrally related* to the faulty design and construction of FCD/I structures. Various mechanisms of corruption and resource misappropriation were identified from the available press reports.[28] These mechanisms and related malpractices can be grouped according to the various stages of work: (a) Selection of *inappropriate* designs of FCD/I structures; (b) Awarding of contracts through *collusion* between the functionaries concerned; (c) *Improper* execution of construction, repair and maintenance; (d) Overbilling and *unwarranted* payments; (e) *Misappropriation* of resources for flood relief and rehabilitation; and (f) *Absence* of proper enquiries and systems of accountability.[29] Apart from corruption and misappropriation *per se*, other forms of *unproductive* expenditure in the name of FCD/I constructions involved lavish and disproportionate expenses incurred during 'inaugurations' and visits by various dignitaries.

Public Information and People's Responses

During 1990, various seminars and workshops were held on flood-related issues. One of this was an 'exclusive' Flood Action Plan seminar on the 'Special Economic Study'. This was *not* made open to all interested Bangladeshi professionals—not to speak of the general public. In any case, such papers and discussions, however important or contentious, tended to be

intelligible to *only* a small and limited circle of concerned professionals. What little was reported by the news media tended to be devoted to the more ceremonial aspects, and did not appear to have made any great impact on public awareness or opinion.

However, coverage of floods by newspapers was extensive and regular. National and regional papers in Bengali naturally had much greater impact on public opinion and awareness than those in English. At least 23 editorials on floods and related problems appeared in the newspapers during the period May-October, 1990. These press reports, editorials and commentaries provided the nearest thing to an *open public discourse* in the country on floods and their consequences. However, despite a wide variety of views on the subject, there still remained certain significant 'gaps' in this public discourse. Issues which did not get adequate coverage were mostly *environmental* ones, including fisheries, livestock, forestry, and related ecological domains.

Flood-affected people were not necessarily indifferent, ignorant or inactive about their predicaments. Press reports corroborated the existence of *people's awareness* and *collective initiatives* to cope with floods and related problems. The reasons behind instances of such popular mobilization included allegations about faulty FCD/I works, dishonesty and malpractices of the concerned functionaries, the inefficiency or inactivity of agencies entrusted with finding solutions for flood problems, etc. Thus, people in different parts of the country were found to have held protest meetings and processions; to blockade *(gherao)* the offices of the local administration to make them act promptly and efficiently; and to defy directives aimed at banning protest rallies and public assembly, despite the presence of security forces to enforce such edicts.

However, these instances of popular mobilization and activism did not always prove to be effective in making the Administration and concerned agencies respond to people's demands. Nor were interventions by the people themselves necessarily successful in solving their problems in all cases. For example, in some instances, breaching of embankments aimed at draining out flood-water led to even greater inundation.

At the same time, in cases such as *Beel* Dakatia, the Administration and its security forces beat a quiet retreat in the face of massive protests by *thousands of men and women*. It is significant that despite considerable press coverage, the people of *Beel* Dakatia and their problems were mostly

ignored by the government-controlled radio and television. Notably, it was *only after* security clampdown orders had been openly defied by the people, and breaches made in the embankments, that *both* the ruling and the opposition parties were found to have taken public positions about Beel Dakatia through statements made at the national level.

There were other, somewhat less dramatic, instances of popular mobilization from other parts of the country which were aimed at dealing with a variety of flood-related problems. At the least, these instances demonstrated that the people of Bangladesh did not lack the inherent predisposition to cope with their own problems. However, there were *structural limits* to how far they could go, given the sheer *scale and magnitude* of the problems concerned. Nonetheless, there appeared to be room here for *judicious policy interventions*. These could be directed at augmenting the organizational and coordinating capabilities of popular initiatives on a much larger scale—as contrasted to virtually 'displacing the people' from the picture by technocratic alternatives in the tradition of FCD works to date, including the Flood Action Plan.

Trends & Hypotheses

In retrospect, the events up to late October of 1990 corroborated earlier predictions[30] of (a) the possible occurrence of *minor* famines in flood-affected pockets of the country, and (b) *cumulative delays* in the 'processing' of the Flood Action Plan, given the uncoordinated institutional matrix within which it had to operate. Correspondingly, a set of hypotheses about possible future trends can be advanced on the basis of the analysis so far.[31] These are specified as follows:

Hypothesis 1: Given the likely delays in processing the Action Plan's paperwork, physical construction of some of its envisaged FCD works might well be initiated *before* all the required investigative and feasibility studies have been completed, and their results publicly debated. This is quite probable, given the presence of massive vested interests linked to national and multinational construction firms, lobbying for the contracts of such physical works.

Hypothesis 2: If such reckless steps were indeed taken, then these might well lead to a series of ecological and environmental disasters in various parts of the country—perhaps even on the scale of Beel Dakatia.

Such apprehensions cannot also be ruled out for the urban-industrial centres of the country, including the capital Dhaka, given the recurrent failures in the design and implementation of urban flood protection works.

Hypothesis 3: The track record to date would make it rather probable that execution of the massive physical works of the FAP would be associated with at least some degree of misappropriation of resources. This might well result in the creation of the kind of 'water traps' indicated above, caused by faulty design, inferior materials, incomplete construction, inefficient maintenance, and other related malpractices.

Hypothesis 4: If the scenario outlined above were to be realized in the longer run, then it might well provoke popular anger and resistance—perhaps on a scale even greater than those evidenced in Sirajganj and Beel Dakatia in 1990.

Any such 'unintended consequence' of the Action Plan could, of course, be a very positive outcome, if the expression of public outrage were to lead to really meaningful popular participation in flood protection programmes. Indeed, perhaps only thus could the *common property resources of land and water*, vital to the survival of the poor majority, be harnessed in ways which could ensure meaningful progress towards the broader goals of poverty alleviation and sustainable development.

Perspectives on the Flood Action Plan

The Flood Action Plan, in its present form, is clearly not comprehensive enough to cope with the social-institutional and environmental dimensions of flooding in Bangladesh. Nor is it adequately sensitive to distributive questions about 'who gains' and 'who loses' from not only floods, but also purported 'flood control programmes'. In a paradoxical sense, the edifying objective of involving the real 'beneficiaries' of flood control programmes in designing and implementing the plan is turning out to be almost literally true. This is also symptomatic of some of the 'conflict of interest' situations obtaining in the institutional mechanisms entrusted with implementing the Action Plan.

The real content, and probable outcome, of the Action Plan is thus likely to be at a considerable *social distance* from the concrete reality of flooding and the ways in which it afflicts the poorest segments of the people of Bangladesh. In one sense, simply getting the 'paperwork' of the plan duly

completed appears to have become *an end in itself, with its own sets of local and expatriate beneficiaries*. Attainment of this objective does *not necessarily* have anything to do with the concrete experience of living and coping with floods. To that extent, the ordinary people of Bangladesh can be seen to have become caught up in a complex game between donor agencies and their local counterparts, but having little say on how that game is actually played out. While the 'aid and consultancy game' is nominally undertaken in the 'name of the people', the people themselves appear to have remained helpless spectators, watching from the sidelines, if at all.

Policy Implications

General Considerations

The policy implications drawn out below follow sequentially from the preceding discussion. They are based on certain *criteria of assessment* which stress protection of the national interests, public accountability and equity, while emphatically discouraging 'conflict of interest' situations and pseudo-scientific methods of project formulation and implementation.[32] Some of these policy implications were also put forward in earlier reports last year.[33] Furthermore, many of the recommendations below were firmly endorsed by the report of the national Task Force on the Flood Action Plan, presented earlier this year.[34]

Reappraising the Flood Action Plan

Perhaps the most crucial recommendation which can be made at this stage is that of commissioning a critical re-appraisal of the FAP and its underlying strategy by an independent body. This would be particularly justified, given the lack of public consultation and other repressive circumstances which had characterized the genesis of the Action Plan. Several quite specific rectifying measures could be incorporated in such a reappraisal. To begin with, the *logical inconsistencies* in the Plan document should be removed—with all the necessary adjustments in the contents of the FAP which that might entail. Furthermore, the so-called 'Eleven Guiding Principles'—embodying pre-judgements about the outcome of investigative studies—should be subjected to serious re-examination.

In addition, certain amendments to the FAP could also be considered under the ambit of the proposed review. One would be to extend coverage of the Action Plan to the flooding problems of Greater Chittagong and the Chittagong Hill Tracts. Another area deserving more intensive attention is the coastal belt in the south-western region, with its embankments and polders, many of which are waterlogged. Vital issues of national interest concerning the conservation of common property resources should be examined, given the widespread prevalence of shrimp-growing business interests in these polders, with little concern for the destruction of the environment and its impact on the poor majority.

The proposed reappraisal of the Action Plan and its 'guiding principles' should preferably be entrusted to *a committee of independent professionals who are known to have had no past involvements, or any existing vested interests, in the continuation and implementation of the FAP*. Furthermore, in the *national interests* of Bangladesh, a *moratorium* should be put on FCD *constructions* until such a review has taken place, and the findings have been fully disseminated for discussion and debate by the general public and its elected representatives.

A critical reappraisal of the FAP on these lines could well lead to major revisions in its contents and time-schedule. Nonetheless, such an exercise would be eminently worthwhile. The reformulated FAP would be *invested with far greater legitimacy* than it has ever had since its inception. Furthermore, such considerations would also carry considerable weight with the *general public and tax-payers of the donor countries themselves*.

Institutions and Functionaries

As a general maxim, the institutions and functionaries dealing with flood protection programmes should operate within a framework which satisfies certain criteria which are indispensable for the protection of the national interest of Bangladesh. Firstly, the 'division of labour', or of functions and responsibilities, should ensure that a *system of checks and balances* is in operation. Secondly, care should be taken to ascertain that no individual or agency performs dual or multiple functions where there is *conflict of interest* between one such function and another. Thirdly, following from the above, all involved institutions and professionals must be seen to be *publicly accountable*, e.g., through periodic reviews by independent evaluators.

The institutional 'division of labour', i.e., the respective responsibilities and functions of the FPCO, the BWDB, the MPO, the RRI, etc., as well as the Ministry of Flood Control itself, should be reviewed in accordance with the principles stated above. To begin with, the unwieldy institutional matrix dealing with the approval and implementation of flood protection programmes ought to be rationalized. This means that unnecessary elements have to be weeded out from the plethora of committees, councils, organizations, agencies, etc., presently in existence. Furthermore, the national and international institutions involved should be encouraged to operate with greater coördination, so as to reduce needless duplication of activities.

As noted by the Task Force on the Flood Action Plan, the role of the FPCO and the *composition* of its 'core panel of experts' should be subjected to serious scrutiny.[35] Firstly, there is the matter of removing 'conflict of interest' situations. Thus, no professional, however competent, should be 'sitting on judgement' as a member of the panel of experts if he/she knowingly has profit-making, or other income-earning, interests in any of the agencies undertaking implementation of FAP components. Secondly, as the Task Force has already recommended, "... the level of competence of all local and expatriate consultants should be subjected to rigourous professional scrutiny."[36] The FAP and other flood protection programmes are *too vital* in the way of public goods to be left in the hands of 'less than competent' consultants with short-term gains to make for themselves. *It follows that the government should critically review the present composition of this 'core panel of experts', and alter it if necessary, in order to safeguard the national interests of the country.*

It may be noted in passing that some infusion of new blood within the 'core panel of experts', particularly through recruitment of professionals of higher calibre and unquestionable integrity, might well prove to be immensely beneficial to the country. Such a step would also help to remove the basis of any possible allegation that the members of a particular group have been arranging to get themselves recurrently employed in the successive phases of the Flood Action Plan, since its very inception. Furthermore, given the somewhat peculiar circumstances under which the FAP was launched under the Ershad regime, all appointments to vital positions in the agencies concerned with plan implementation ought to be critically reviewed in order to remove any vested interests which might have continued to persist.

Future Progress of the Flood Action Plan

Serious consideration should be given to the Task Force's view that some of the so-called 'supporting' studies of the FAP are *logically antecedent* to its 'main activities'. This would not only call for a redefinition of the *interrelationships* between different components of the Plan, but also *a new priority ordering* among them with additional 'conditionalities'. For example, physical constructions of the structural components of the Action Plan should take place *only after* the critical environmental and other prior investigative studies have been completed, and their findings publicly disseminated and thoroughly debated.

Furthermore, given the addition of at least one new study (SES), as well as the proliferation or merger of other FAP components, a re-statement of the modified Plan and the interrelationships between its present components are called for. Improvements are badly needed in the periodic reporting on the progress of the FAP. The *Review Report* of the FPCO should contain much more detailed professional updates, as might be expected of a project of this magnitude and, further, ought to be circulated on a wider scale.

Protecting Urban-Industrial Centres

In contrast to what has happened so far in Dhaka city, industrial establishments should be kept *inside* the protected zone, rather than outside. If such flood protection works are technically not feasible, then attempts should be made to shift the industrial units themselves to safer locations. In most urban centres presently subject to waterlogging, the primary thrust should be on improving the drainage system and ensuring its proper maintenance. This would take care of not only excess rainwater, but also industrial effluent and organic pollutants contained by the stagnant water. Protective measures to save towns from river erosion would require vigilance all the year round. Such efforts should *not* be made in *ad hoc* or piecemeal fashion—as has often tended to be the case. Rather, the agencies responsible should be *instructed to prepare in advance* to cope with such recurrent, and predictable, contingencies.

Dealing with Social, Economic and Demographic Disruptions

Adequate measures need to be devised to protect valuable land from erosion and inundation, particularly those containing vital and valuable assets such

as schools, hospitals, industries, power installations, trading centres, storage godowns, roads, railways, ferry-*ghats*, etc. The usual problems associated with protective works for such assets need to be addressed decisively, e.g., planning and getting funds for projects in time, weeding out corruption and malpractices in the stages of execution, etc.

Furthermore, pre-emptive steps should be taken to prevent loss of movable assets, or at least, to minimize the extent of such losses. For example, people should be encouraged to design their houses in ways such that these can be dismantled quickly, and reassembled into structures that can stay afloat, such as rafts or makeshift boats. This would not only allow other household goods to be put aboard, but also could serve as emergency shelters.

Flood-affected people usually take refuge on raised embankments and levees anyway, along with their livestock. It might thus make sense to have flood shelters in the form of raised earth mounds in almost every village, since people would then be able to move to such points with greater ease and lesser reluctance. Given the proximity of such shelters to their homesteads, they would also be able to guard their deserted settlements more effectively against thieves and criminals, particularly those moving on mechanized boats.

Since flooding is virtually endemic in certain parts of the country, regular measures to ensure safety and provisioning could be arranged well in advance. Thus, in areas highly prone to floods, it would make sense to have permanent and ready stores of dry food, drinking water, essential medicine for typical diseases, fuel and energy sources, means of water transportation and localized communication, etc. Preparation against flood-generated problems should include measures to cope with, and *prevent, environmental pollution*. Thus, advance preparations could be made to dispose off corpses and carcasses, without letting them rot in water because of the lack of dry land for burial. Correspondingly, appropriate measures could be taken to cope with intrusions of saline water before serious damages to farming systems, trees and vegetation cover set in.

None of these need be terribly 'high-tech' stuff. Indeed, much could be done by observing and building upon the indigenous practices of the floodplain peasantry, well-versed in coping with flood conditions. At the same time, simple low-cost technologies and more efficient organizational structures could certainly be brought in from outside to augment indigenous

'life-support systems' and prevent environmental pollution. For example, having groups of 'barefoot' doctors, trained to cope with typical intestinal diseases, along with an emergency stock of appropriate medicine, could enable people in remote localities to take care of themselves until further assistance from outside could arrive.

With respect to relief workers and medical teams, the propensity to concentrate activities in easily accessible localities, particularly with better accommodation facilities, needs to be strongly discouraged. This would help to ensure that emergency rations and medical aid reached *bona fide* flood-stricken people marooned in remote and relatively inaccessible hamlets in the rural interior. More generally, purported 'relief activities'—concerned essentially with self-seeking publicity on the part of the individuals and organizations involved—ought to be systematically discredited. This would help genuine humanitarian assistance to reach those who needed it most. The press could play a vital role here by exposing these dubious instances of 'providing relief'.

Coping with Famines

There are self-evident reasons for taking steps to prevent the occurrence of the kind of near-famine conditions observed in certain parts of the country in 1990, particularly Kazipur in Sirajganj. If the failure of 'exchange entitlements'[37] leading to such extreme situations are to be adequately tackled, then attention must be given to restructuring the prevalent food distribution system to suit such limiting conditions of human distress. Firstly, the official agencies entrusted with distribution of *non-market* relief goods would have to display greater awareness and sensitivity to the way flood conditions were affecting people. Secondly, more accurate ways of monitoring and responding to the apprehension of starvation and illness, arising from *lack of access to food and medicine* would have to be evolved. If the behaviour of Ministers and Deputy Commissioners (D.C.) during 1990 are characteristic, then nothing short of a *drastic reorganization* of the flood relief administration would be called for. In essence, more competent, concerned and honest functionaries and institutions would have to be entrusted with such tasks.

Another set of complementary institutional measures to fend off possible famine conditions would be to *increase the access* to food and medicine of

flood-affected people by *enhancing their income-earning capabilities.* Programmes could be activated so that they could procure such essentials through self-provisioning, or from incomes earned on the market. While floodplain dwellers are known to be experienced and resourceful about surviving under these conditions, sound policies can augment such innovative and indigenous practices.

Thus, relief and rehabilitation activities could be devised in ways which would generate forms of wage and/or self-employment which accorded with the customary patterns of occupational shifts and self-provisioning practised by the people under flood conditions. Of particular significance would be measures directed at preserving, and further augmenting, the *access* of the flood-affected poor to vital *common property resources.* Availability of such *ecological reserves* would enable them to continue to survive through their *own* efforts—individual or collective—rather than having to become *increasingly dependent on relief and aid* coming in from outside.

Countering Socio-Economic and Demographic 'Chain Reactions'

It is much more difficult to propose remedies for the socio-economic and socio-demographic 'chain reactions' triggered off by floods and river erosion, leading to possible landlessness, destitution, and out-migration of those severely affected. Countering such processes call for social-institutional policy interventions which have the potential of stopping such chain reactions before they get out of hand. For example, the ready availability of employment and credit may be able to prevent the compulsive logic of debt dynamics forcing a peasant family to mortgage or sell its land and livestock.[38] Equally, the availability of community-based shelters in the vicinity, along with rehabilitation programmes during the most acute periods of distress, might prevent the destitute from setting out on *uncertain migration paths,* with little guarantee of eventual survival or security. Such measures would be of particular benefit to destitute *women and children, who face the most acute forms of social and physical insecurity* under flood conditions.

There are other, longer term, socio-demographic problems of a *structural* nature for which no 'readymade solutions' are available. One is to find ways of settling the *nadishikosthi* people, uprooted by river erosion and

inundation, in locations which are not socially or physically insecure. The typical pattern is for the migrants to settle in the *extreme margins* of the deltaic reaches—becoming increasingly more vulnerable to natural hazards and subject to repeated uprooting and migrations. It is also in such areas, usually *charland*, that the rule of law is least effective.[39] This makes it extremely difficult to provide a modicum of social protection to such destitute migrants against the extortions of local-level power-holders and landlords.

Special Measures for Women and Children

Measures need to be devised to enable women to continue to perform their traditional roles under conditions of flooding and resulting disruptions. The kind of preparatory activities noted earlier could include advance community-based stocking of essential consumption goods which would enable women to cook food, purify water, nurse and care for their children, etc. Existing policies of the flood relief administration and implementing agencies should be altered, wherever necessary, *to ensure that women receive foremost priority in the distributive process.* Such measures would also help to ensure that *children* received their due share of whatever assistance was available, since their *access to it depended primarily on that of their mothers.*

It is difficult to find adequate policy measures which could cope with the intractable problems of *physical and social insecurity* confronting women—particularly those who are young—under conditions of flooding, and consequential destitution and migration. This is a problem area where really concerned women's organizations and NGOs could perhaps come up with realistic and viable ideas. There is little to be expected in this matter from the presently existing administrative machinery.

It is absolutely essential to take steps to ensure that the schooling and health of children did not suffer due to flooding, particularly in the areas subject to waterlogging for years together, such as Beel Dakatia. Concerned official agencies and NGOs could take steps to construct schools and clinics well above the water-level, and also arrange for necessary transportation for taking the children there and back. No formidable technical problems are involved. The net effect would also accord with *equity* objectives, since it is mostly the *poor* who are stuck in such waterlogged areas and cannot afford to send their children to school in more secure flood-free environments.

Coping with Environmental Hazards and Related Socio-Economic Conflicts

Policy recommendations in this area cover two broad themes. The first pertains to arresting processes which are leading to potentially *irreversible* damage to the environment. The second, which is an important special case of the first, is concerned with *preventing the takeover and destruction* of vital common property resources and ecological reserves by profit-making private commercial interests. Policy-makers need to be explicitly aware of the fact that tackling these environmental issues is *inseparable* from the problem of coping with ruthless socio-economic forces, which often have the capability of inflicting murderous violence, as well as influencing decision-makers at the very top of the Administration.

Thus, prompt and decisive legal measures should be taken against those who breach polders and embankments in order to *forcibly* convert arable land into shrimp-fields. Steps should be taken to enforce existing laws, particularly in cases where shrimp-growing is explicitly prohibited by government regulations. If deterrent measures do not work, then those responsible should be penalized, e.g., be put on trial in the courts of law. The press and other news media could play a complementary and courageous role here by giving more prominent coverage to such activities which destroy common property resources vital to the rural poor.

Perhaps, one of the most crucial measures which can be taken to safeguard environmental conditions is to put a *moratorium* on those FCD/I constructions which are likely to have damaging consequences. This would allow environmental impact assessment and other investigative studies to be completed, and their results publicized, *before* any such major physical interventions were undertaken, including those proposed by the Action Plan. To illustrate, FAP Component 17 should be particularly concerned to find ways of not damaging or destroying the *gene-pools* which underlie the *bio-diversity* of fishes and other aquatic life-forms. Unless such measures can be devised and properly implemented, construction of physical structures which could have adverse effects on the above should *not* be allowed to proceed.

Indeed, given experiences such as that of Beel Dakatia, new polders and compartments should *not* be constructed without being preceded by rigourous technical, socio-economic and *environmental* studies. Such investigations must take account of continuing siltation and land formation

by river activity and consequential rise in the levels of river-beds and the surrounding floodplain. This would help to ensure that the disastrous mistakes of the past, evident from the present state of many FCD/I structures, are not repeated. Equally, the cost-benefit analysis used to decide whether such physical constructions should be undertaken, *must* take account of short and *long* term damages to the environment, including ecological reserves and other common property resources.

On the urban-industrial front, the environmental degradation resulting from the flood protection works of Dhaka city provides critical lessons for perceptive policy-makers. For example, flood walls and embankments which have led to *internal waterlogging*, as well as pollution of stagnant water from industrial effluent and blocked sewerage channels, should be either demolished, or properly re-built with adequate drainage mechanisms. In particular, a strict *moratorium* should be imposed on the *construction* of further flood protection works, until an *integrated* solution to the city's drainage and sewerage problems, along with flood protection, can be found.

Institutional Reforms and Reducing Dependency

Finally, the complex dimensions of flood protection programmes bring forth certain intractable problems of a general nature, to which there are no easy solutions. For example, how can short-term consultants be made *accountable* for the long-term consequences of their 'counselling and expertise'? Equally, how can the existing structural bias in favour of the rich and the powerful (say, shrimp-growing businessmen) be countered? What would make the bureaucracy, the law and order machinery, donor agencies and the local power structure more concerned about the interests of the majority, who are poor and weak? In what ways could the Administration, as well as concerned donor agencies, be made *more sensitive, responsive and accountable* for the long-term environmental and socio-economic consequences of the FCD/I structures that are built?

Policy-makers in the Government of Bangladesh, as well as among the donor community, might do well to ponder over these questions. This could also be presented as a matter of their *enlightened self-interest*, since the poor majority might otherwise begin to see possible association between such national agencies and donor organizations on the one hand, and the local-

level predatory social forces damaging their means of livelihood on the other.

Agencies charged with the responsibility of flood protection programmes must be explicitly directed to ensure that all FCD constructions are *complete*, so that breaches, gaps or leakages do not destroy the *indivisibility* of the protective structures. This implies that repair and maintenance works must be carried out in good time, and that requisite funds should be made available punctually, without any undue institutional constraints. This is a tall order, given the prevalent state of organizational inefficiency and malpractice in Bangladesh.

More generally, flood protection works should be made *less* capital-intensive and dependent on foreign aid. In fact, greater *self-reliance* can be expected to be associated *with more labour-intensive* techniques which rely on *mobilization* of the local population and their collective ingenuity and initiatives. The programme of the Action Committee in Beel Dakatia provides an outstanding instance of a perfectly home-grown and indigenous model of popular mobilization, which can be constructively refined with technical assistance brought in by a committed and visionary leadership.

The management of relief and rehabilitation in flood-affected areas needs to be grossly overhauled. Apart from weeding out processes of resource misappropriation, the penchant for self-seeking publicity on the part of certain politicians and bureaucrats ought to be strongly discouraged by the top leadership of the country. Only thus would ordinary people begin to see the difference made by a democratically elected government in comparison to the autocratic and corrupt regime which preceded it.

All functionaries involved in the construction and maintenance of flood protection works, as well as flood relief, ought to be made *publicly accountable* for their performance. For example, penalty clauses should be included, and be enforced against the concerned contractors and supervising officials, if FCD constructions subsequently displayed technical defects. Equally, it could be made mandatory that payment of a certain proportion of the bills for construction and repair works would be *withheld* until a given time period had elapsed *without* the concerned structure showing any defects.

Enlightened policy-makers amongst donor agencies could also take steps to remove some of their own propensities which serve to generate corruption and malpractices. Disbursing 'aid and loans' in contexts where

they are clearly *not needed* encourages temptation and creates scope for misappropriation of resources. If the real objective of such activities is to assist the people of Bangladesh to find sound ways to cope and live with floods, then the propensity to build unnecessary—and even counter productive—FCD structures ought to be discouraged by enlightened donors as well.

There is enough evidence to show that, in certain cases, Bangladesh can become *worse off* as a result of receiving external assistance, the eventual results of which go against the national interests and the needs of the country's poor majority. In other words, *some aid is best not taken.* Consequently, the mere 'availability of funds' ought *not to be sufficient reason* for inflicting unnecessary constructions, and consequential disasters and debt repayment burdens, upon the unborn generations of the future.

Notes

1. The various newspapers and other documentary sources used for this study are listed under *References*.
2. In fact, there was significant restriction on access to such public domain information. See Adnan [1991c] and RAS [1990b].
3. These reports included: UNDP/GoB [1989], ISPAN [1989], FEC [1989], World Bank [1989a; 1989b] and GoJ [n.d.]. Annex B of World Bank [1989a: 48-55] provides a summary of these plan documents.
4. See World Bank [1989a: 23].
5. See World Bank [1989b] and FPCO [1990a; 1990b].
6. BARC [1989]. Reproduced in Adnan [1991c: 95].
7. Task Force [1991].
8. One example is provided by the study on floodplain fisheries (FAP Component 17). See World Bank [1989b: 86].
9. FPCO [1990d: 12-14].
10. Task Force [1991].
11. Cf. Task Force [1991], pages 4-11 and 6-2.
12. This was, in part, due to changes in the procedures of plan approval, some of which were associated with the downfall of the previous regime at the end of the year.

Another critical factor was the relative inactivity of the various governmental committees which had been entrusted with overseeing and approving the Action Plan.

13. The abbreviation FCD/I stands for 'flood control, drainage *and/or irrigation*'.
14. World Bank [1989b: 7], para 2.8.
15. *Holiday*, 10 August 1990.
16. Sen [1977; 1981].
17. This is deliberately oversimplified for the convenience of the non-technical reader. Those interested are referred to Sen's original writings [Sen, 1977; 1981].
18. See MPO [1985], RAS [1988], BARC [1989] and Minkin [1989].
19. *Ittefaq*, 28 July & 11 August 1990; *Bangla*, 17 August 1990; *Sangbad*, 5 October 1990.
20. *Sangbad*, 20 November 1990. Field visit by RAS' staff to Polder No. 20, published in Adnan [1991c: 72-73].
21. *Ittefaq*, 6 October 1990.
22. See discussion in Rahman [1989: 47-48].
23. *Sangbad*, 20 November 1990.
24. Adnan [1991c: 72-73].
25. *Janata*, 28 & 29 September 1990; *Sangbad*, 29 September, and 1 October, 1990; *Inqilab*, 29 September, and 2 October, 1990; *Banglar Bani*, 29 September 1990.
26. World Bank [1989a: 13], Figure 2.5. For discussion, see RAS [1990a; 1990b]. Press reports by *Sangbad*, 27 September 1990; *Janata*, 29 September 1990.
27. See Adnan [1991c: 54-58] and RAS [1990b: 13].
28. For details of the press reports concerned, see Adnan [1991c: 86-92]. It needs to be *categorically stated here that the discussion is entirely illustrative. It does not constitute charges made by us against anybody, or any agency, regarding their involvement in such malpractices.* To the extent that any allegations might exist, these have been made by newspapers and other publications. We have simply *cited such public sources, without necessarily endorsing their views.*
29. Press reports alleging the existence of such malpractices are documented in greater detail in Adnan [1991c: 86-92].
30. See discussion in RAS [1990a; 1990b] and Adnan [1991c].
31. Cf. RAS [1990b] and Adnan [1991c].
32. These criteria of assessment are specified in detail in Adnan [1991c].
33. Cf. RAS [1990a; 1990b].
34. Task Force [1991].
35. Task Force [1991], page 6-2.
36. *Ibid.*

37. Sen [1977; 1981]. See discussion in Adnan [1991c] and RAS [1990b].
38. See theoretical arguments and some historical evidence in the work of Amit Bhaduri [1976; 1977; 1983]. Further discussion of the issues are available in Adnan [1984; 1985].
39. Cf. earlier study by Adnan & Mansoor [1978].

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CHAPTER NINE

PERSPECTIVES FROM THE DRY SEASON INTERACTIONS BETWEEN RIVER ACTIVITY, SEDIMENTATION, WATERLOGGING, FLOODS AND WATER CONTROL STRUCTURES

Shapan Adnan

Introduction

This paper is concerned with discussing the somewhat ignored perspectives on the interrelationships between river activity, sedimentation, water-logging, floods, and water control structures which emerge from a look at the dry season. The evidence used for this purpose comes mostly from the period November, 1990, to April, 1991, which roughly corresponds to winter and spring in Bangladesh. An attempt is made to interrelate the distinct patterns characterizing the dry and wet seasons of the year, so as to arrive at an integrated overview of the annual cycle.

Limitations of the Evidence and Method of Analysis

These patterns have been pieced together mostly from various secondary sources, including reports by professional agencies, government publi cations, academic and seminar papers, as well as the national press. The

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secondary information has been supplemented to a limited extent by fieldwork to collect primary data from certain areas such as *Beel* Dakatia and polders in the saline belts of Greater Khulna.

It should be pointed out at this juncture that these 'dry season perspectives' have not been derived on the basis of any great technical expertise in the various scientific disciplines concerned. Rather, these points and conclusions are reached primarily from the vantage-point of social science, making use of available scientific knowledge.

Layout of the Contents

The paper is laid out as follows. Assessment of the patterns of river activity, sedimentation, waterlogging and floods during the dry season is followed by a look at their major social, economic, demographic and environmental consequences. The role of various institutional, structural and management factors, as well as malpractices related to various water control structures, are taken up next. Public discussions and press reactions on these phenomena are reviewed to assess the level of public information and awareness on these issues vital to the economy and environment of Bangladesh. Some concluding remarks and policy implications are drawn out in the context of these perspectives from the dry season.

Patterns of River Activity, Flooding, Waterlogging and Sedimentation

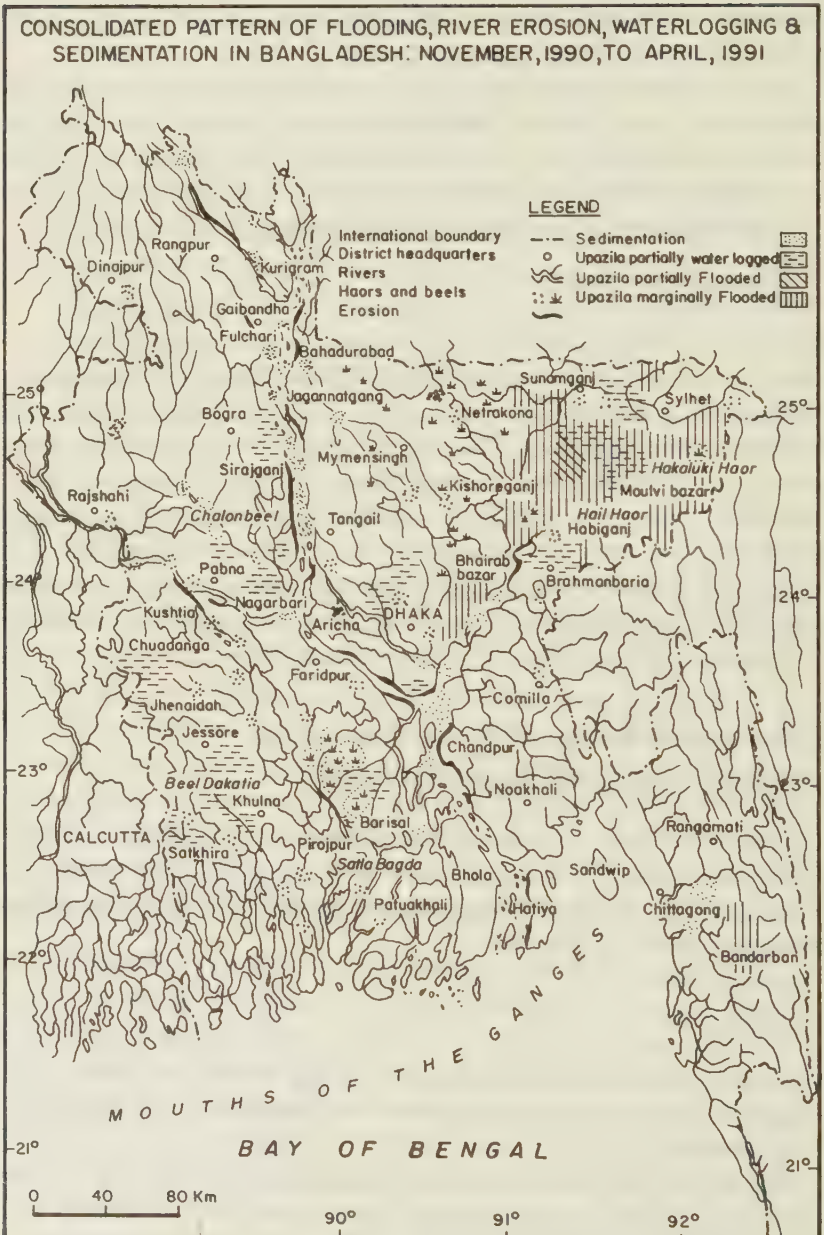
Country-wide patterns of flooding, waterlogging, river erosion and sedimentation are outlined below. A convenient visual summary of these patterns is provided in the figure 1, which is based on information from the period November 1990 to April 1991.

Flooding

As might be expected, straightforward flooding was of very minor significance during the dry season. Reports of inundation came in at the very end of the period.

During the first week of April, flash floods began to occur in the Greater Sylhet and, to some extent, Greater Mymensingh, regions in the north-east,

Figure 1



Source : Research & Advisory Services, November, 1991

as shown in the figure 1. Swelling of mountain streams and rivers from heavy rainfall in Bangladesh and the Indian state of Assam resulted in the breaching of local embankments and the inundation of *haors* (low-lying water bodies) downstream. Comparable flash floods took place in the Bandarban district of the Greater Chittagong Hill Tracts at about the same time, swelled by cross-border water flows. Despite these minor instances, the evidence clearly indicated the *virtual absence* of any extensive flooding in the country during these months corresponding to the 'drier half' of the annual cycle.

River Erosion

Erosion by river activity continued unabated during these months, despite the the recession of floodwaters. As shown in the figure 1, this was true of virtually all the river systems of the country, including the major ones centreing around the Brahmaputra-Jamuna, the Ganges-Padma and the Meghna.

A critical feature of river erosion was the fact that the process was found to take place when the water level receded, as much as when it increased.[1] Furthermore, erosion was reported all through the dry season—stretching from November to April. Indeed, the evidence strongly demonstrated that river erosion in Bangladesh was a *perennial* process which, furthermore, was *not necessarily* linked to heavy rains or high water levels.

Waterlogging

Waterlogging could be viewed as a somewhat peculiar form of flooding resulting essentially from drainage congestion. The phenomenon had also been observed earlier, during the monsoon period of 1990.[2] This kind of submersion resulted from a variety of causes, over and above river activity, as will be discussed later.[3] However, as is evident, neither rainfall, nor spillover of river flows, was a major factor causing waterlogging during this season.

The figure 1 shows the overall spatial pattern of waterlogging in the country during the dry season. The predominant instances were found in the south-western zone of the country, covering stretches of Greater Khulna, Barisal and Jessore, followed by Greater Kushtia. Some of these locations

experienced virtually continuous waterlogging, with water remaining stagnant for many years. Some of these waterlogged tracts in the south-western zone were enormous in size. Examples are provided by *Beel* Dakatia,[4] the Satla-Bagda cross-dam area, six *beels* of Satkhira and depressed tracts of Chuadanga.[5]

Extensive waterlogged tracts were also observed in other agro-ecological zones of the country. In the north-west, waterlogging existed in tracts of Greater Pabna, Rajshahi and Bogra. The pre-eminent cases here included Chalan *Beel* and an area of 3000 acres under the Hurasagar FCDI sub-project.[6] Another set of waterlogged areas was to be found in several *haors* of Greater Sylhet and Mymensingh in the north-east. Minor waterlogged tracts were reported from Greater Dhaka and Comilla.[7] The incidence of such waterlogging, despite the absence of any significant precipitation or riverine inundation, poses interesting questions about their underlying causes. These issues are taken up for discussion below.

Sedimentation and Formation of Shoals and Char Areas

Perhaps the most striking phenomenon observed during the dry season was sedimentation, leading to the formation of shoals and *chars* in most of the riverine tracts of the country. While this constituted a process which was, so to speak, the very 'inverse' of flooding—it was *by no means unrelated* to the occurrence of floods during the wet season.

Sedimentation of finer silt and coarser sand, in varying proportions, resulted in their accretion and the raising of the heights of river-beds. Juxtaposed with declines in the level of water flows during the dry season, the net result was the greater visibility of literally hundreds of shoals and *chars*, or accreted landmasses, as shown in the figure 1.[8] In extreme cases, rivers dried up entirely, or in stretches, and the river-beds so bared were even observed to be used for cultivation, grazing, and other purposes during this season.[9]

Numerous *chars*, as well as shoals lying close to the water's surface, were reported on the Brahmaputra-Jamuna, the Ganges-Padma, as well as many of their tributaries and distributaries. The latter included the Teesta, the Atrai, the Baral, the Garai, the Arial Khan, the Madhumati, the Kumar, the Nabaganga, the Bhairab, the Bhadra, the Pusur, the Bishkhali, the old

Brahmaputra, the Dhaleswari, etc.[10] While sedimentation and silting was most noticeable in the south-western zone, emergence of *chars* and shoals were also significant along the Meghna and its tributaries, including the Surma, the Kusiyara, the Kalni, the Titas and the Gumti.[11] Further afield, sedimentation also affected smaller rivers in the Greater Chittagong region, including the Karnaphuli and the Shangkho (Sangu).[12]

Sedimentation was by far the most pronounced and universal process characterizing the dry season—*common* to all the major river systems of Bangladesh. It was accompanied by the raising of the levels of river-beds, and a general reduction in the depth of river flows.[13] As will be taken up later, this process of 'filling up' of rivers had complex causes and an equally varied range of consequences, many of which were disruptive for the economy and environment of the country.

At this juncture, however, the key point which needs to be emphasized is that the process of sedimentation and *char* formation can be identified as a critical contributory factor in *causing floods* during subsequent wet seasons. This is because the volume and discharge capacities of river channels are reduced by sedimentation—leading to correspondingly greater extent of 'overbank spillovers'. This critical interrelationship between river activities in the dry and the wet seasons reflects a striking, but none too obvious, *causal* linkage between *sedimentation and flooding*—even though, these might otherwise appear to be quite unrelated processes. Significantly, the obverse linkage is also true and more evident: flooding causes sedimentation.

Related Processes

Other related processes took place in the river systems of Bangladesh during this period. These included upstream intrusion of salinity and declining navigability along the rivers.[14] Drought and symptoms of desertification[15] were also reported from the landmasses adjacent to some of the rivers, associated with declining levels of surface and groundwater—including the limiting case of rivers drying up entirely.[16]

While these processes are noted because of their undoubted significance, they cannot be treated in any great depth in this paper due to constraints of time and space. However, some of these aspects will be touched upon below in the discussion of environmental and socio-economic issues.

The Case of Town and Bazars

Like the rural areas, towns and *bazars* experienced waterlogging and river erosion during the relatively dry months of November-April. The damages caused to trading towns such as Chandpur and Bhairab Bazar were considerable.[17] Town protection works in Sirajganj and Rajshahi were threatened by the Brahmaputra-Jamuna and the Ganges-Padma respectively.[18] On a smaller scale, the bazar townships of Beanibazar and Barguna in the north-eastern and southern extremities of the country were subjected to erosion by the rivers Kushiara and Bishkhali respectively.[19] The same applied to the township of Kumarkhali.[20]

However, as also noted for the wet season,[21] the problem typically experienced by towns was *not* flooding, but rather waterlogging—caused by bottlenecks and impediments in their drainage systems. This was reported, amongst others, for the townships of Satkhira, Dhamrai and Chapainawabganj.[22]

Social, Economic and Demographic Consequences

Interaction between river activities and man-made FCDI interventions generated diverse social, economic and demographic processes. While such consequences of flooding, erosion and waterlogging have tended to be noted more frequently, the impact of sedimentation, *char* formation and declining surface and groundwater levels has tended to be less 'visible'.[23] An attempt is made here to *link* these distinctive consequences of the dry season with those of the wet period. Indeed, it is worth noting that certain socio-economic and socio-demographic consequences were found to be *common* to both seasons, despite the fact that they had been triggered off by very *different* circumstances.

The discussion below considers, in turn, the effects of each of the forms of river activity and water-related phenomena noted above. The possible structures of causation involved are taken up for discussion later.

Sedimentation and Reduction in Water Levels

The process of sedimentation led to the raising of river-beds and the formation of *chars* and shoals. Combined with reduction in the rates of

discharge, these resulted in a series of social, economic and demographic disruption. Thus, decline in water levels, sometimes even to a vanishing point, adversely affected socio-economic groups such as boatmen and fishermen, who were dependent on the river and its water for their livelihood. Economic hardships confronted the respective communities in the affected areas.[24] Instances of decline in fish output, resulting in the loss of income and employment for fishermen, were reported from various riverine tracts of the country.[25] Thousands of fishing households were reported to have changed over to occupations involving daily wage work in order to survive, or emigrate from their home areas in search of better conditions elsewhere.[26]

Decline in surface and groundwater levels made it increasingly difficult, if not altogether impossible, for mechanized irrigation devices to operate—thus seriously disrupting agricultural production needs during the dry winter and spring months.[27] Low-lift pumps and deep and shallow tube-wells in many areas were reported to have remained inactive because of these reasons. The results of such constraints to cultivation included considerable unemployment, loss of incomes and, in certain cases, acute crises of the survival of the peasantry.[28]

Sedimentation and declining water levels also had adverse effects on industries which needed to use large quantities of water from the river. The premier case in point was provided by the paper mill at Pakshi, situated on the bank of the Ganges, which was virtually under threat of closure at one time.[29]

Perhaps the most striking, 'visible' and widespread consequence of the sedimentation and reduced water discharge rates was deterioration in the navigability of river systems, manifested in the emergence of *chars* and shoals, as well as inadequate draught for water transports. Communication was disrupted along the major waterways of the country, affecting motorized vessels and, in certain rivers, even non-mechanized country boats. Movement of ferries for both road and rail transport across the Padma-Jamuna were severely affected. Ferries had to move on longer, riskier, and more tortuous routes.[30] Certain services were temporarily suspended; in some cases, ferries were reported to have got stuck in shoals and *chars*.[31]

Disruption of river transport increased the difficulties and costs of conveyance for passengers and goods. Exorbitant toll collections were made on alternative routes.[32] During certain periods, virtually all cargo-handling on

the major ferries and waterways came to a halt. Perishable goods were often wasted. These processes, in turn, induced relative excesses and shortages in the supply of goods in other areas, distorting the respective market prices and, more generally, reducing the level of efficiency of the national economy.[33] Examples were provided by inordinate increases in the price of oil and fuel in northern areas. Prices of perishable goods, such as potatoes, which could not be reached to their terminal markets, fell drastically.[34] A general downturn in the economy and rise in the unemployment level were reported.[35]

Sedimentation and its direct and indirect consequences led to certain kinds of socio-economic 'chain reactions'. Those losing their means of livelihood and sources of employment were often forced to sell their land and assets, in a process characterizable as pauperization and destitution.[36] On the other hand, new *charland* became the subject of contention for possession and control between rival claimants—occasionally leading to murderous conflicts between local power-holders and their armed retainers.[37] In the process, the landless and the land-poor tended to lose out on their *bona fide* claims to land, even though existing laws gave them higher priority as potential allottees of such *charland*.[38]

Erosion

As noted above, erosion by river activity was a perennial activity—in the sense that it was found to have persisted through all seasons of the year. Its socio-economic and socio-demographic consequences during the dry season of 1990-91 were qualitatively no different from those observed during the earlier wet season.[39]

Thus, river erosion destroyed homesteads, land, crops, vegetation, and forms of social and physical infrastructure, including FCDI structures such as embankments.[40] People whose homesteads, lands and property were eroded displayed similar responses, irrespective of the season of the misfortune. In some cases, erosion took place so fast, or unexpectedly, that they were unable to shift their movable assets in time.[41]

Those losing their homesteads, usually attempted to find shelter on raised structures including embankments, roads and public buildings such as schools.[42] Not all were successful. Many people became destitute overnight.[43] Long processions of uprooted migrants, known as *nadishikosti*,

moving towards urban centres in search of food and shelter, became a familiar sight.[44] Amongst the destitute, change of occupation was often the sole *strategy of survival* available. Thus, farmers from Dashmina in Barisal, whose land had been eroded, were reported to have taken up rickshaw-pulling and wage labour.[45]

Waterlogging

Waterlogging during the dry season, in itself a somewhat *paradoxical* phenomenon, also had problematic consequences. It might be expected that waterlogging would compensate for the relative scarcity of water during these dry months. However, the evidence suggests that a *localized excess* of water, remaining stagnant in depressed areas and blocked drainage channels, could produce very disruptive socio-economic and socio-demographic consequences. Indeed, such adverse effects were little different from those observed for waterlogging in the wet season.[46]

To begin with, agricultural production could become impossible, given protracted waterlogging exceeding a critical depth.[47] In other cases, standing crops were damaged or destroyed by gradual submersion.[48] Production and harvesting costs went up accordingly, and there were also comparable difficulties with transportation.[49] More generally, waterlogging affected the cropping pattern—by changing the possible crop-mix, cropping intensity and timing of crop production. Factors such as the above led to consequential unemployment, change of occupation, out-migration and various survival strategies which are typically found to be adopted by people under conditions of great duress.[50]

Flooding

In some ways, it is ironic that flooding should come last. However, during this dry season, the only notable instance of flooding occurred at the very end, as noted earlier. These flash floods created havoc along the rivers of the Greater Sylhet region, destroying standing crops, livestock, trees, homesteads, and physical infrastructure such as embankments, roads, electricity transmission structures, educational institutions, etc.[51] Minor instances of flood damage were reported at other times during the dry season.[52] Apart

from these socio-economic consequences, death and disease took their toll on the affected people—particularly those who were marooned by flood water.[53]

Environmental Consequences

The critical features distinguishing the environmental conditions of the dry season, as contrasted with periods of flooding, were *primarily* associated with the decline in the levels of surface and groundwater.[54] These, in turn, were related to lower rates of precipitation and discharge by the river systems, caused by factors which will be taken up in discussion below. In fact, the pattern was such that one adverse consequence gave rise to another, resulting in a kind of 'chain reaction' of environmental degradation. Furthermore, the situation was often aggravated by man-made interventions on river flows within, or outside, Bangladesh, in the form of ill-planned water control structures such as FCDI constructions, which produced environmentally counterproductive results.

As noted above, decline in surface water levels, taking the form of the 'drying up' of rivers and other water bodies such as *khals* and *beels*,[55] was reported from many river systems of Bangladesh. Certain sections of some rivers were reported to have dried up completely, i.e., become devoid of water. Not surprisingly, adverse impacts on the stock and *diversity* of species of riverine fisheries were reported.[56] Almost certainly, the same applied to all other forms of aquatic life in these water bodies—including probably *irreversible* losses to the pre-existing 'gene pool'.

Reduction in surface water flows was associated, not surprisingly, with a decline in groundwater levels.[57] The latter, in turn, meant less water available for extraction by shallow and deep tube-wells, whether for irrigation, or for drinking and cleaning purposes. Often, the situation would be worsened by unplanned extraction of groundwater. Longer term environmental repercussions were apprehended to be much more serious, and included the dying of trees from acute drought.[58] If such processes persisted over time, the natural balance of the agro-ecological system in the affected areas could well be seriously disturbed.[59]

Another critical symptom of environmental disruption was the rise in *salinity* levels of both land and water.[60] This was, in part, due to upstream diversion of water from rivers—resulting in greater intrusion of more saline water from its downstream reaches.[61] Such increased salinity and associated

environmental consequences also resulted from the misuse or malfunctioning of pre-existing FCDI structures, e.g., sluice gates, water regulators, etc.[62] Available studies on the effects of rise in salinity levels in southern Bangladesh clearly indicate that there are destructive consequences for vegetation cover including crops and certain fruit-bearing trees, livestock, as well as particular species of fish and aquatic life forms.[63]

In certain areas, the sediment load deposited by rivers consisted largely of coarse sand rather than fine silt.[64] In such cases, soil fertility was adversely affected—as contrasted with the more usual phenomenon of enhancement of fertility due to siltation from flood-water. Indeed, such deposition of thick layers of sand, along with prolonged drought, lowering of surface and ground water levels, gradual destruction of vegetation cover and rise in soil salinity, provided symptomatic indicators of what sections of the press described as a process of 'desertification'.[65]

It was striking that even during the dry season, river erosion and minor flooding continued to submerge or wash away trees of various kinds from village homesteads and orchards—contributing to a kind of 'deforestation' process.[66] Equally, protracted waterlogging was associated with the 'rotting' of stagnant water and the decomposition of submerged organic matter.[67] Apart from providing suitable grounds for the breeding of mosquitoes, such stagnant and polluted water itself became a source of skin infections and other diseases for both human beings and livestock.[68] Even loss of certain kinds of fish due to protracted waterlogging was reported.[69]

Underlying Factors

Overall Causal Relationships

As noted in our earlier studies, the flood-related processes under consideration were generated by a multiplicity of causes: structural, institutional, technical, etc.[70] Indeed, even criminal negligence and related malpractices were found to be at work.[71] Evidence from the dry season of 1990-91 not only supported these earlier patterns, but also shed new light on the *overall causal interrelationships* underlying the *annual pattern* of flooding, sedimentation and other forms of river activity in Bangladesh.

The critical perspectives emerging from this annual overview can be summarized as follows. Firstly, the processes of sedimentation and *char*

formation during the dry season serve to *reduce* the discharge capacity, i.e., the volume of water per unit time, which could be carried by rivers and waterways. Furthermore, the heights of sea-level and river-beds are raised as a cumulative result of sedimentation over the years.[72] Consequently, over time, the waters flowing through these rivers are less likely to be fully discharged by their drainage channels. The net result is a *cumulative increase over time in the chances of flooding*—since, even a similar volume of water would have to overflow the river banks to a greater extent compared to the situation before the incremental sedimentation took place.

Furthermore, the mixed sediment load carried by flood-water ranges from coarse sand to fine silt. Under normal conditions, the coarser sand tends to be deposited earlier than the silt.[73] Typically, such deposited sand is found close to the river-bed and the adjacent banks, whereas the finer silt is carried further into the interior by flood-water, to be eventually deposited on inundated fields, including cropland.

However, this 'normal' pattern can change dramatically in the event of a *breach* in the embankment and other water control structures along the river bank. In that event, the velocity of flood-water pouring in through the breach can be sufficiently high to transport with it much greater amounts of the coarser sand. That is, the very existence of weak and inadequate FCDI structures on river banks *increases* the risk of sand being deposited on arable land by flood-water fanning out into the interior through the breaches made in such 'flood protection' structures.[74]

The discussion below looks into further details of the causal relationships underlying these processes which also appear to be integrally related to the state of the environment of the country. While some of the factors identified below can be regarded as 'natural'—many others are 'man-made', in the sense of being purposive interventions. Ironically, these counterproductive man-made factors often turn out to be water control structures which had been constructed with quite different objectives in mind.

The apparent paradox embodied in scenarios like this will be somewhat resolved when we look at some of the structural, institutional and technical aspects of the matter, as well as the varied mechanisms of resource misappropriation associated with the construction and operation (O&M) of FCDI structures in Bangladesh.

Sedimentation

The key point to emphasize at the outset is that sedimentation and *char* formation in the rivers traversing Bangladesh is by no means new or unexpected. Indeed, the process has been going on for thousands, if not millions, of years, and there is nothing extraordinary about the patterns described above. Furthermore, while short-term factors may have influenced the trends somewhat, these should not be allowed to eclipse the role of the long-term forces at work.

In particular, the most important factor behind the massive sediment load carried by these river systems appears to have been earthquakes. In a recent study of the Brahmaputra within Assam of India, Goswami concludes that, "There appear to be rapid aggravation associated with earthquakes followed by periods of relatively slow removal . . . Thus recurring tectonic disturbances in the region seem to have pronounced effects on the channel configuration of the Brahmaputra in Assam. . . The present high rate of denudation of the Himalayas may be attributed mainly to the rapid uplift of the mountain system and to the high susceptibility of erosion of geologic formations within the intense monsoon rainfall regime . . ."[75] Much of what happens in the tract of the Brahmaputra in Assam probably applies to the lower stretches of the river within Bangladesh—since, the prime factor responsible for the sediment load still remains the tectonic activities upstream.[76]

Superimposed on these natural forces are the effects of man-made interventions on the river systems flowing from upper riparian tracts to the sea through Bangladesh. Such interventions consist largely of FCDI constructions and other water control structures built by both India and Bangladesh on the numerous *common* rivers flowing between them.

The press in Bangladesh, naturally enough, has focused on the adverse effects of the Farakka Barrage on the Ganges, just across the border in India. While the devastating impact of Farakka cannot be underestimated, it is also important to bear in mind that most of the effects of this barrage impinge *only* upon the tracts of the Ganges-Padma. In other words, the operation of the Farakka Barrage *cannot* explain the various processes taking place in the Brahmaputra-Jamuna and the Meghna basins, despite certain popular beliefs to the contrary.

However, given this qualification, there appear to be good reasons to associate the offtake of water at Farakka with the high level of sedimentation,

char formation and increased salinity in the downstream reaches of the Ganges-Padma within Bangladesh.[77] During the period under consideration, there was no formal agreement on water-sharing between the two countries. In effect, India had been taking unilateral decisions about the volume of water to be released for use by Bangladesh, and this amount had been declining over time.[78] It was reported that, at one stage, most of the gates of the barrage were closed. The eventual outcome of these considerations would accord with the fact of the mighty Ganges drying up to a trickle near the Hardinge Bridge for several months of the year.[79]

The press reported that apart from the Farakka Barrage, many other water control structures, roads and physical structures had been built by India on upstream tracts of 'common' rivers. The impact of these constructions had led to *increased* sedimentation, *char* formation, *reduced* navigability and other adverse environmental effects in the downstream reaches of these rivers in Bangladesh.[80]

However, there were also other factors, *internal* to Bangladesh, which contributed to sedimentation of its rivers and the adverse environmental and socio-economic processes. Many ill-planned, faulty, incompletely constructed, damaged or unrepaired FCDI structures were responsible for reduction in water flows and sedimentation of river-beds.[81] Wherever such constructions had created impediments aligned *transverse* to the natural line of gravity flow, these had acted as 'sand traps' where much of the sediment load of river and flood water had been deposited.[82]

Another contributory factor was inefficient, or untimely, dredging of rivers. However, it should be borne in mind that dredging of its two thousand miles of currently navigable riverways is *not* an economically viable proposition for Bangladesh, and can only be justified for major river routes and approaches to the ferry terminals (*ghats*). Nonetheless, inefficient dredging of even such vital tracts were reported in respect of the terminals at Aricha, Sirajganj and Daulatdia, as well as Mongla port.[83] The performance of the BIWTA (Bangladesh Inland Water Transport Authority) —the government agency responsible for dredging and navigation—did not appear to be particularly impressive. There were reports of dredging and related work being taken up in an ill-planned manner, or much later than required.[84]

Waterlogging

There were, so to speak, 'dozens of Beel Dakatias': instances of large-scale waterlogging in the country. Waterlogging during the dry season was obviously *not* caused by rainfall. Rather, the reasons had much more to do with the bad design and faulty construction of water control structures and the inefficient operation and improper maintenance (O&M) of various drainage mechanisms.[85]

As noted earlier, extensive waterlogging was reported from several areas in the south-west. Failure of concerned agencies to repair damaged sluice-gates and other FCDI structures, as well as to drain out trapped and accumulated water from the 1987-88 floods, had resulted in seven upazilas of Greater Jessore and Khulna being waterlogged.[86] Another three upazilas of Jessore were reported to have been waterlogged because rivers and canals had silted up, with little attempt to dredge and maintain their water flows by concerned agencies. Construction of roads, canals and cross-dams on the Indian side of the border were reported to have silted up the Bhairab and Mathavanga rivers, leading to the waterlogging of thousands of acres of land in Chuadanga and Satkhira districts in the south-west.[87]

Another major instance of waterlogging was provided by the Satla-Bagdha irrigation project covering around 72,000 acres in the Gopalganj, Barisal and Pirojpur districts.[88] Its embankments had been widely breached by the floods of 1987 and 1988. Due to lack of adequate maintenance, the long drainage canal had silted up—thus preventing the accumulated water from draining out of the project area.

Another belt of waterlogging centred around the Chalan Beel in Greater Pabna, also noted earlier. Due to a faulty regulator at Char Andharmanik of the Hurasagar Project, nearly 3000 acres of cultivable land in Shahzadpur upazila were waterlogged.[89] Due to ill-designed and faulty construction, about half of the Tarash-Baghabari project area in Chalan Beel remained submerged during the dry season.[90] Ill-designed cross-dams to provide flood protection in Chatmohar upazila of Greater Pabna had resulted in perennial waterlogging instead.[91]

Waterlogging in Greater Sylhet typically resulted from the silting up of the drainage channels and canals of rivers and *haors*. Normally, such *haors* would drain out during the dry season to a certain extent. However,

abnormal waterlogging was reported from Nalua *Haor*, the Kusiyara river and the Kuiakhali canal.[92]

Apart from faulty FCDI works, any unplanned construction, which choked existing drainage channels, held the possibility of generating waterlogging. Sometimes, these processes were manipulated by vested interests, as was reported from Sariakandi of Bogra and Sujanagar of Pabna.[93]

River Erosion and Flooding

As noted above, there was little flooding during the dry season. However, the flash floods in hilly areas served to illustrate the critical linkage between 'dry season' sedimentation and subsequent flooding, as postulated earlier.[94] Siltation of river-beds in the Greater Sylhet region had reduced their discharge capacity: when torrential rain swelled streams on both sides of the border, swift floods ensued quite predictably.

Factors causing river erosion did not appear to be particularly different during the dry season, except for the obvious reduction in volume and velocity of water flow compared to the wet monsoons.[95] Rapid decline in forest areas and vegetation cover might be related to loosening of soil and its greater vulnerability to erosion by river activity.[96] Roads and embankments which were not built according to the required specifications, also proved vulnerable to river erosion.[97]

Nonetheless, it was somewhat paradoxical to find that embankments constructed for the *very purpose of providing protection against floods*, should themselves be found to be collapsing so frequently in the face of river activity.[98] Explanations for this perplexing phenomenon were not entirely unrelated to the institutional and financial aspects of FCDI works, as indicated below.

Management and Institutional Failures

These aspects of the matter pertain to limitations in the capability of concerned institutions to cope with problems generated by the dry season processes and their varied social, economic, demographic and environmental consequences. What is problematic about the issues here is that the sharp divide between institutional inefficiency *per se* and covert malpractices, involving misuse and misappropriation of resources, becomes extraordinarily 'blurred' on some occasions.

Institutional inefficiency and management failures in coping with such problems tended to occur in certain 'standard' forms. The agencies concerned either failed to take decisions—or took the wrong ones. Even if they took a decision, they often failed to implement it *in time*—usually because the requisite funds became available *too late*. These made any later efforts somewhat useless, if not altogether wasteful.

In addition, there were problems of *coordination* between different institutions carrying out complementary activities. For example, this was pre-eminently the case with the BIWTA and the BWDB. Even though the two agencies were responsible for separate tasks related to the same river systems, they obviously were not in the habit of coordinating their activities. Such problems often reduced the efficiency of both parties—making the eventual outcome of their work relatively ineffective.

Some of these issues can be illustrated by evidence from the dry season of 1990-91. Thus, disruption of ferry services across the Padma-Jamuna took place due to heavy sedimentation around the *ghats* (jetties) at Daulatdia, Aricha and Nagarbari. Though dredging was urgently needed, it was reported to have been initiated much later than would have been optimally useful. This management failure led to more costly dredging operations.[99]

Similarly, capital dredging at Mongla port had not begun as late as March, 1991, even though the activity had been scheduled to start much earlier.[100] The delay cost the public exchequer around seven million takas. With respect to dredging of the major national waterways, the BIWTA claimed that it had been sanctioned Taka 19.4 million only, whereas the amount required was estimated to be around Taka 67 million.

Instances of planned FCDI project activities not being executed, or becoming counterproductive due to delays in proper decision-making, were reported from various parts of the country.[101] These included cases of cyclone-damaged embankments which had not been repaired,[102] and delays in implementation of projects stretching for decades.[103] There were also instances of projects which had became uncertain due to delays in the approval and allotment of funds.[104]

Such delays often led to manifold increases in project costs, compared to the initial estimates.[105] For example, purchase of a dredger at an excessive price,[106] and a tenfold increase in the costs of a project were reported.[107] The incidence of such 'expensive delays' was particularly inexplicable in those cases where the concerned authorities had been warned in due time about

impending problems and the remedies required. In fact, the *recurrence* of such 'delays', or 'lags' with *a certain timely precision*, would appear to be not entirely random. Rather, at least some of these systematic delays were probably not unrelated to the misuse of resources, as will become apparent from the discussion below.

More generally, inefficient project management and the lack of coordination between agencies involved with the approval, financing and execution of FCDI projects, entailed a net cost for the economy *as a whole* in terms of wastage of skilled manpower and resources. Many such instances were reported by the press.[108] Some projects were quite evidently wasteful —involving piecemeal or temporary measures at controlling floods and stemming erosion or sedimentation—the net results of which were conveniently 'washed away' soon after.[109] Equally, some sections of Dhaka city's recently built R.C.C. flood-walls were quite redundant, e.g., the stretch from Jatrabari to the 'China-Bangladesh Friendship Bridge' near Postogola.[110] These constituted instances of the sheer wastage of public funds—whether mobilized from domestic or external sources. The same applied to projects which were literally abandoned halfway—sometimes involving a significant amount of 'sunk costs' which could no longer be recovered.[111]

It is evident from the discussion that such institutional efficiency and management failures involved substantial costs for the nation as a whole. A critical question at this juncture pertains to whether some groups lost out, or gained from, such outcomes.

There is little doubt that the poor and the distressed had to bear the brunt of these costs, e.g., in terms of not being given due compensation for the land requisitioned from them for FCDI projects,[112] or because they were deprived of the relief goods and rehabilitation programmes intended for them.[113] One of the most poignant instances of administrative inefficiency and callousness leading to such waste was that of nearly 500 cartons of dry food, intended as relief for flood-affected people in Sirajganj, being literally dumped into the river. Apparently, the food had become unfit for human consumption due to bureaucratic delays in distribution.[114]

By the same token, there must have also been groups and functionaries who were 'gainers', i.e., those who positively *benefited* from such institutional inefficiency and management failures.[115] Such actors and

agencies, and the mechanisms of misuse and misappropriation of resources involved are taken up next for further examination.

Misuse and Misappropriation of Resources

The possibility of deliberate misuse, or misappropriation, of public resources cannot be entirely ruled out in the various instances of institutional inefficiency and managerial incompetence noted above. Significantly, the national press put out dozens of reports *explicitly* alleging that misappropriation of resources had indeed taken place. For obvious reasons, it was not possible for us to cross-check or verify most of these allegations. Nonetheless, the discussion below looks at some of these press reports in order to work out a typology of the possible modes of such resource misallocation.[116]

One set of allegations pertained to irregularities in tendering of works and the selection of contractors. Reported cases involved alleged collusion between officials and contractors in the sale of the approved forms, depriving the state of revenue;[117] nepotism in the award of contracts;[118] and the sale of a dredger under conditions which promoted private vested interests at the cost of the public exchequer.[119] A rather controversial case pertained to the award of the dredging contract for Mongla port to a particular international contractor, as against a reportedly better offer from another.[120] Apparently, there were serious lapses in terms of the prescribed official tendering procedure for international contracts.

Significantly, this was not the only financial scandal involving *foreign suppliers and multinational companies* operating with counterpart national agencies of Bangladesh. One press report alleged that a dredger had been bought on the basis of tenders *restricted* to French suppliers only. Apparently, this had been done on the basis of the personal directive of the then President, General Ershad.[121] The consequence for the national exchequer was that much more was paid for the purchase than the prices offered for comparable equipment by other international suppliers.

Another major scandal involved the misuse of a Japanese grant intended for buying a fleet of motorized boats for flood relief.[122] In this case, too, there was allegation of interference in the tendering procedure by General Ershad and his cohorts. However, the matter also appeared to involve 'underhand' competition between Japanese corporations vying to get the

bid.[123] Reports on the affair were picked up by the Japanese press and it was publicly debated in the Japanese parliament on 23rd April, 1990.[124] Bureaucratic inefficiency in the commissioning of these Japanese boats was also hotly discussed by the parliament and press in Bangladesh, following the cyclone of 29th April, 1991, when their services were badly needed for rescue and relief activities.[125]

There were wide-ranging allegations about corruption in the execution of FCDI works, e.g., excavation of river-beds, construction of embankments, putting up of sand bags and porcupines, etc.[126] Abnormal profits were made by reducing costs and inflating bills of payment by using devious means. Costs of production were reduced by using inferior materials, not ensuring adequate supervision, and underpaying workers in relation to stipulated rates.[127] In one extraordinary case, earth dug out of an embankment was shown to have been used for earthworks on the same structure.[128] Inflated bills were made on the basis of fictitious papers showing work had been done where none, or relatively little, had actually been accomplished.[129] Such exercises involving excessive allocations and payments, would almost certainly have required some degree of *collusion* between contractors and the government officials supposedly supervising their work, possibly involving underhand 'kickbacks' to the latter from the former.

Among such malpractices, a heinous form of fraud was used to deprive people, whose land had been requisitioned for FCDI works, of their due compensation. Typically, the concerned officials of the Ministry of Land, in collusion with local brokers, would bill the acquired land at much higher prices than what they actually paid out in compensation to the real owners—if at all—while pocketing the difference themselves.[130] Such land revenue and settlement officials (*tehsildars*) were also reported to have been involved in depriving poorer landowners, whose plots had been eroded by river action, of the right to re-possess their original plots—if and when these re-surfaced.[131] Correspondingly, these officials were alleged to have illegally transferred the rights over such re-surfaced *charlands* belonging to the poor to powerful and influential people, who had bribed them adequately for the purpose.[132]

A rather sinister activity reported during the dry season referred to deep trenches being dug just alongside the right bank of the Brahmaputra-Jamuna in Sirajganj.[133] This had been ostensibly done to excavate earth for filling up depressed areas in Sirajganj town. However, such excavation had

obviously weakened the river bank and was likely to trigger off severe erosion and subsidence of the river-bank during the next floods. The whole affair virtually amounted to an act of deliberate sabotage. It was possibly undertaken during the dry season by vested interests which also expected to get the next round of contracts for 'flood protection' works on the damaged sections of the river-bank.

Unscrupulous quarters were found to have taken advantage of the disruption of normal ferry services, resulting from sedimentation and *char* formation. Alternative routes were created across the Jamuna, involving new *ghats*, or points of embarkation.[134] A new set of *izaradars* or toll-collectors sprung up who were reported to have used extra-legal force to divert river traffic and passengers through those points where they could collect exorbitant taxes.[135] It was paradoxical that this could happen despite the existence of other routes and ferry *ghats* close by—run under the auspices of none other than the BIWTA. It remained a mystery as to why such forcible surplus extraction could take place *despite* the proximate presence of officials of the very governmental agency controlling inland water transport in the country (i.e., the BIWTA).

There were also allegations about direct embezzling of the resources allocated for FCDI works.[136] This included underpayment and misappropriation of wheat allotted for projects,[137] and a rather suspicious 'robbery' at the warehouses in which materials of the Muhuri Irrigation Project were kept.[138] There were charges of *corruption across the board* pertaining to various other water control works, including a scheme of *haor* protection.[139]

Significantly, none of these allegations in the press appeared to have prompted the authorities concerned to initiate formal enquiries to verify the respective charges. Even more disturbingly, in one solitary case it was reported that despite irregularities being uncovered by an enquiry committee, no remedial or punitive actions had been taken.[140]

It is also sobering to note that while some of these malpractices dated back to the previous regime—well-known for its rampant corruption—comparable activities continued to be reported even after the fall of General Ershad in early December, 1990. It would thus appear that despite the change of top leadership at the national level during the period under consideration, the routine and customary malpractices of the *implementing bureaucracy* had perhaps continued to operate as usual.

Public Discussions and Press Coverage

Public Discussions

At the biennial conference of the Bangladesh Economic Association, held in January, 1991, a paper was presented on *The Political Economy of Flood Protection Programmes* in Bangladesh.[141] At least one national daily picked up the key theme of this paper in the headline of its report on the conference, which could be roughly translated as follows: "*In the aid game, the people are helpless spectators.*"[142] The press report went on to cite the paper as stating that, in addition to the technical and geographical aspects of flood protection, *the social, economic and environmental aspects had to be taken into account as well.*

On 11th April 1991, the national parliament witnessed an unscheduled debate on the widespread problem of river erosion.[143] Even though the subject was not on the day's agenda, Members of Parliament took the floor one after another for nearly ninety minutes, competing with each other to hold up the problems of their respective constituencies. The speakers included stalwarts from the government and the opposition. In the end, the Leader of the House announced that the Minister concerned would make a statement on the subject later, which would cover the problem of erosion for the country as a whole. However, no substantive policy statement regarding river erosion and bank protection was reported after this parliamentary discussion.

Press Coverage

During this six-month long dry season, the national press gave much attention to the interrelated problems of declining water levels, the process of sedimentation, the formation of numerous *chars* and shoals, as well as severe disruption of the navigability of rivers. In fact, press coverage of these problems was quite rich and detailed, as might be apparent from the source materials cited for this paper itself.[144]

The predominance of *sedimentation* in press coverage of river activity, lasted from November to March. From April, reports on flash floods and consequential damages to embankments and FCDI structures assumed greater

prominence. River erosion was reported all through this long dry season, reflecting its *perennial* character, as noted above.

By and large, the press also provided documentation of the social, economic, demographic, environmental and even political consequences of river activity and *char* formation.[145] Apart from reporting current trends, there were special features by the press on the long-term difficulties and problems of the men and women living in the *char* areas, as well as the uncertainties of uprooting which haunted them continuously. However, there was no detailed coverage of the special problems faced by *women and children*.

While environmental features of the dry season such as decline in the levels of surface and groundwater were widely reported—these were obviously not treated analytically by the press. However, there were graphic descriptions of these processes, including case studies of their destructive consequences on human settlements, vegetation cover, etc.

As noted above, the press provided considerable coverage to allegations of corruption and resource misappropriation related to FCDI projects. However, such reports were short on concrete details which could be subjected to further verification by the concerned authorities. Provision of more precise details would have helped to augment the credibility of many of these allegations.

Furthermore, there were certain subjects which received far less attention from the press than their importance might have warranted. For example, there was not much *critical* evaluation of the major FCDI programmes being currently pursued by the government and donor agencies, including the Flood Action Plan.[146] Nor was there any critical commentary on the views of political parties on these issues, including those specific to the dry season. But, on the other hand, the parties did not really have much to say on the subject which went beyond elementary rhetoric and populism. The press could thus hardly be blamed for not reporting a *non-existent* policy debate between political parties on these issues. However, there was indeed a reasonably coherent discussion of these policy issues in newspaper editorials, which also attempted to influence public opinion and policy-makers.

Newspaper Editorials

A considerable number of newspaper editorials were written during this period on the issues under consideration.[147] These provided the nearest thing to a 'mass-level' *public discourse* on the socio-economic and environmental

consequences of floods and associated FCDI projects.[148] As might be expected, the most frequently covered topics were sedimentation, *char* formation and decline in the navigability of rivers, along with their consequences for people and the economy.[149]

At least some of these writings were critical of current policies and the performance of concerned agencies in various projects, e.g., the Shalla-Itna embankment and the waterlogging in Satla-Bagda project and Beel Dakatia.[150] The problems identified included inordinately lengthy delays, irresponsibility of the concerned agencies and functionaries, administrative rivalries and in-fighting, misuse and misappropriation of resources, etc.[151] A leading daily pointedly observed that certain agencies and functionaries concerned with FCDI projects were often found to be less interested in coming to grips with the real problems than with the opportunities for misappropriating resources.[152]

Equally, the fact that nearly 500 cartons of food had to be 'thrown into the river' because they had not been distributed in time to the needy and had thus become unfit for human consumption, was not allowed to pass uncensured. The act was held out as a clear example of callousness and gross insensitivity to public opinion on the part of the administration in Sirajganj.[153]

Much of the contents of editorials dwelt on *policy issues* and alternative approaches to these problems. One view concentrated its firepower on the inefficiency of project *implementing* agencies only. An alternative view attempted to look at the stages *prior* to implementation such as policy briefs, planning and decision-making, in order to provide a better appraisal of the *underlying causal processes* and, on that basis, suggest more appropriate policy options. These more serious editorials concluded that floods and related problems could *not* be adequately solved on the basis of 'hurried research', conducted on a short-term basis.[154] It was also noted that development planning for the nation could not be left to the whims of a few individuals, but rather had to take account of the country's *socio-economic, geo-political and environmental imperatives.*[155]

While some of these editorials focused only on current trends in river activity and FCDI project performances, others took a longer term view, critically analyzing the changes taking place over time.[156] Thus, one editorial provided a critical review of the problems of waterlogging, pollution and health hazards which had resulted from constructing the so-

called Dhaka city flood protection works.[157] That town protection schemes in other parts of the country were also notorious for graft and corruption by the concerned agencies was also explicitly noted by a leading daily.[158] Some of the more incisive editorials went on to pinpoint the *mismanagement of various water control structures*, and their *counterproductive environmental consequences*, as perhaps *the most critical factors responsible* for the worsening of the already acute problems of flooding, drainage and sedimentation.[159]

Another notable aspect of some of the more reflective editorials was their ability to approach the flood-related problems in an *international* context, with some candid discussion of the *realpolitik* of the matter. This was particularly consistent with the perspectives emerging from the dry season—since it was precisely during this period that the superior bargaining power enjoyed by the upper riparian countries became acutely 'visible'.

It was advocated, firstly, that a comprehensive solution—as contrasted with piecemeal patch-ups—required a collaborative endeavour with the upper riparian states.[160] Secondly, it was pointed out that possible solutions for these long-term problems of the country ought to be based on some kind of a national consensus—rather than the parochial vision of partisan politics—in order to ensure the best interests of the nation and the people.[161] In this connection, the following passage from an editorial appears to be particularly relevant: "It cannot be denied that hindrances at the international level have to be overcome by means of (i) national unity which is always promoted by democracy... and (ii) a careful handling of international situations as they arise from time to time. This means a conscious cultivation of diplomacy on our part."[162]

Concluding Remarks

Institutional aspects of dry season processes and their bearing on problems related to water resources constitute a significant area requiring greater critical assessment than has been the case so far. The lack of coordination between concerned agencies such as the BIWTA, BWDB, port authorities, etc., calls for appropriate policy interventions. Measures have to be devised to discourage concerned official agencies from becoming involved in institutional malpractices which work against the interests of the

poor majority, as well as the maintenance of a healthy and balanced environment.

Given the evidence above on river activity and sedimentation in the country during the dry season, it is surprising to note that very few of the programmes related to the Flood Action Plan and other FCDI projects have displayed any great concern or sensitivity about these vital issues in the background. Instead, there appears to have been a 'one-dimensional' focus on the respective projects—such that getting the project approved and executed has become an end in itself for the actors, institutions and agencies profitably involved in that game.

Furthermore, serious critiques of the FAP and other FCDI projects, provided by environmentalists, social scientists and even general public opinion as expressed by the press, have often been simply filed away after due acknowledgements and sympathetic noises. The bureaucracy entrusted to deal with these projects has, on the whole, gone about its business 'as usual'. Indeed, without any substantive change in government and donor policy which seriously incorporates such critiques, rather than making merely cosmetic adjustments, the inertia of the concerned bureaucratic and technocratic machinery is likely to favour the continuation of the kind of unimaginative routine operations which have been documented above.

Nonetheless, there still remains considerable room for working on judicious policy analysis, so as to explore the alternative means by which diplomacy on an international scale could help to resolve the problems of coordinated water-sharing and water management between Bangladesh and all the major upper riparian countries involved. Indeed, a *breakthrough* here might prove to be much more productive and worthwhile than all the activities of the Flood Action Plan put together. Putting it another way, if Bangladesh continues to be in a situation where it lacks any significant control on the volume, timing, and rate of discharge of the major river systems flowing through the country, then no amount of FCDI construction can provide any *guaranteed protection* against the interrelated problems of floods, drainage and sedimentation which presently afflict the water management of the country.

The perspectives emerging from the dry season bring into focus the critical consideration that the *shortage* of water—in particular places at particular times—also results in grave threats to the people and the environment of Bangladesh. Furthermore, waterlogging and river erosion

during the dry season add complex dimensions to the conventional view of the flood problem as arising during the wet season only. In fact, some of these are continuous processes operating all round the year. On the other hand, it is also apparent that if measures to control floods lead to either shortage of water at other times, or waterlogging in some places due to faulty drainage mechanisms, then such efforts end up becoming quite counterproductive. A rational approach calls for *integrated* planning and policy-making to cope with the abnormalities of floods as much as droughts, sedimentation, bank erosion and waterlogging. These, in turn, call for a holistic approach to water resources management in Bangladesh, subsuming both surface and ground water, as well as maximal possible co-operation with the upper riparian countries.

Notes

1 Cf. Patterns of erosion during recession of floodwaters, as noted in RAS [1990a; 1990b] and Adnan [1991c].

2 See RAS [1990a; 1990b] and Adnan [1991c].

3 See discussion of the underlying causal relationships in subsequent sections, as well as in the references cited above.

4 This consisted of a polder straddling Greater Jessore and Khulna, with an area of the order of 40,000 acres. For further details, see Adnan [1991c] and RAS [1990b].

5 *Ittefaq*, 8 December 1990; *Bani*, 13 March 1991; *Bangla*, 18 November 1990; *Inqilab*, 5 March 1991.

6 *Ittefaq*, 8 December 1990 and 23 March 1991.

7 *Bani*, 26 November 1990; *Inqilab*, 20 December 1990; *Observer*, 26 December 1990; *Ittefaq*, 28 December 1990 and 20 & 23 January and 8 March 1991; *Sangbad*, 16 February 1991; *Sangram*, 4, 5 & 11 March 1991.

8 *Ittefaq*, 17 November and 21 & 22 December 1990; *Sangbad*, 6 December 1990; *Observer*, 20 December 1990; *Star*, 11 March 1991.

9 *Bangla*, 16 January 1991; *Ittefaq*, 28 January and 6 & 13 April 1991.

10 *Sangbad*, 6 & 29 December 1990 and 1 January & 24 and 29 March 1991; *Observer*, 15, 20 December 1990 and 1 April 1991; *Ittefaq*, 10, 21 & 22 December 1990 and 23 January & 13 February 1991; *Sun*, 15 & 28 January 1991; *Times*, 8 January 1991.

11 *Janata*, 15 December 1990; *Bangla*, 15 December 1990 and 10 & 11 February 1991; *Sangbad*, 11 March 1991.

12 *Sangram*, 1 & 12 March 1991; *Azadi*, 7 April 1991; *Star*, 16 February 1991.

13 *Bangla*, 22 December 1990; *Ittefaq*, 17 February 1991. However, the river-bed of the Jamuna has remained more or less stable according to Coleman [1969] and preparatory studies carried out for the proposed Jamuna bridge. We are indebted to Bruce Currey for bringing these facts to our notice.

14 *Ittefaq*, 18 January and 9 & 22 March 1991; *Sangbad*, 4 February and 1 April 1991; *Bani*, 25 February 1991; *Inqilab*, 2 March 1991; *Star*, 7 March 1991; *Observer*, 1 April 1991.

15 *Holiday*, 26 October & 2 November 1990; *Sangbad*, 22 March & 28 April 1991; *Inqilab*, 12 April 1991; *Sun*, 11 January 1991; *Janata*, 30 March 1991.

16 *Sangbad*, 22 & 29 March 1991; *Ittefaq*, 14 & 23 March 1991; *Bangla*, 10 & 11 February 1991; *Janata*, 12 March and 1 & 10 April 1991; *Inqilab*, 19 December 1990 and 12 April 1991.

17 *Sangbad*, 25 November 1990 and 26 January & 6 April 1991; *Ittefaq*, 8 December 1990 and 20 & 30 April 1991; *Inqilab*, 25 December 1990.

18 *Observer*, 4 & 24 November and 6 & 29 December 1990; *Bangla*, 30 March 1991.

19 *Ittefaq*, 26 February 1991; *Bani*, 9 March 1991.

20 *Ittefaq*, 10 December 1990.

21 See RAS [1990b] and Adnan [1991c].

22 *Observer*, 12 December 1990 and 6 January 1991; *Sun*, 12 January 1991; *Sangbad*, 19 January & 11 February 1991.

23 Cf. RAS [1990a; 1990b] and Adnan [1991c; 1991d].

24 *Sangram*, 12 March 1991; *Janata*, 15 & 27 December 1990 and 17 January, 1 February & 9 March 1991; *Sangbad*, 17 January, 22 March & 5 April 1991; *Ittefaq*, 28 January & 13, 10 April 1991; *Times*, 14 March 1991.

25 *Sangbad*, 4 February, 16 & 29 March 1991; *Ittefaq*, 10, 13 & 16 April 1991; *Janata*, 17 January & 9 March 1991; *Sangram*, 12 March 1991; *Naya Rajniti*, 13 February 1991.

26 This pattern was the inverse of the typical occupational shift observed during the rainy season, when affected farmers shifted to fishing for survival. See discussion in Adnan [1991c] and RAS [1990b].

27 *Bangla*, 15 & 12 December 1990 and 10 & 11 February 1991; *Sangbad*, 19 January, 16 & 22 March 1991; *Inqilab*, 6 & 16 March 1991; *Times*, 17 March 1991.

28 *Ittefaq*, 3 January and 13 April 1991; *Janata*, 17 January and 4 April 1991; *Times*, 14 March 1991; *Inqilab*, 16 March 1991; *Sangbad*, 23 March 1991.

29 *Bangla*, 12 December 1990; *Janata*, 27 December 1990 and 11 April 1991.

30 *Bangla*, 11 April 1991; *Sangbad*, 6 December 1990 and 1 January 1991; *Ittefaq*, 17 November and 27 December 1990 and 5 April 1991; *Millat*, 12 December 1990.

31 *Ittefaq*, 10 December 1990; *Janat*, 10 December 1990; *Sangbad*, 6 December 1990.

32 *Janata*, 20 November & 22 December 1990 and 7 March 1991; *Ittefaq*, 22 December 1990 and 4 February 1991; *Inqilab*, 6 March 1991; *Sangbad*, 24 March 1991; *Bangla*, 11 April 1991.

33 *Bani*, 18 November 1990; *Janata*, 15 December 1990; *Inqilab*, 12 December 1990 and 2 April 1991; *Sangbad*, 6 December 1990 and 4 February 1991; *Sangram*, 9 March 1991.

34 *Janata*, 14 March 1991; *Bangla*, 23 March 1991; *Sangbad*, 3 April 1991.

35 *Ittefaq*, 14 February and 5, 6 & 10 April 1991; *Bangla*, 9 April 1991; *Sangbad*, 5 January 1991 and 6 & 16 February 1991; *Sangram*, 8 March 1991.

36 *Ittefaq*, 28 January and 10 April 1991; *Times*, 13 February 1991; *Sangram*, 2 March 1991; *Sangbad*, 16 March 1991.

37 *Bangla*, 18 & 20 January 1991; *Inqilab*, 2 April 1991. Cf. Adnan & Mansoor [1978] on conflicts for land in *char* areas.

38 During this period, the law on the title to emerging *charland* was changed. The real effect, in practice, was largely adverse to the poor. *Holiday*, 8 March 1991; *Sangbad*, 21 January 1991.

39 See Adnan [1991c; 1991d] and RAS [1990a; 1990b] in which consequences of river erosion have been discussed in detail.

40 *Bani*, 9 & 17 November, 8, 16 & 27 December 1990 and 2 & 9 March 1991; *Bangla*, 21 November, 1990 and 5 & 14 April 1991; *Observer*, 24 November 1990, 6 & 29 December 1990 and 4 March & 7 & 9 April 1991; *Ittefaq*, 8, 10 & 27 December 1990 and 18 & 23 January, 18, 23, 26 & 28 February, 18 March and 5, 6, 7 & 20 April 1991; *Millat*, 13 December 1990; *Inqilab*, 25 December 1990 and 7, 26 & 28 April 1991; *Sangbad*, 6 & 11 January, 5 February, 5 & 7 April 1991; *Sangram*, 1 & 4 March 1991; *Janata*, 14 December 1990 and 21 April 1991.

41 *Ittefaq*, 30 October 1990.

42 *Bangla*, 23 December 1990; *Ittefaq*, 27 December 1990; *Sangbad*, 23 & 26 April 1991.

43 *Ittefaq*, 30 October 1990; *Sangbad*, 12 November 1990 & 21 January 1991; *Bangla*, *27 November 1990; Bani*, 8 December 1990.

44 *Sangbad*, 12 November 1990 and 21 January 1991; *Bani*, 8 December 1990; *Bangla*, 18 January and 30 March 1991; *Janata*, 22 & 29 January 1991; *Ittefaq*, 18 March 1991; *Inqilab*, 26 April 1991.

45 *Bani*, 8 December 1990.

46 See discussion in Adnan [1991c] and RAS [1990b].

47 *Sangbad*, 20 March 1991.

48 *Ittefaq*, 7 & 16 December 1990; *Sangbad*, 9 February and 26 April 1991; *Sangram*, 5 March 1991.

49 *Ittefaq*, 7 December 1990; *Observer*, 12 December 1990.

50 *Sangbad*, 11 November 1990 and 31 January & 6 February 1991; *Times*, 13 February 1991; *Bani*, 13 March 1991; *Akota*, 29 March 1991.

51 *Bangla*, 5 & 6 April 1991; *Sangbad*, 5, 7 & 26 April 1991; *Ittefaq*, 5, 6, 7, 9, 10 & 11 April 1991; *Inqilab*, 6 & 9 April 1991; *Observer*, 7, 9 & 21 April 1991; *Janata*, 21 April 1991.

52 *Sangbad*, 11 January & 23 March 1991; *Ittefaq*, 20 January & 12 March, 1991.

53 *Inqilab*, 6 & 7 April 1991; *Sangbad*, 7 April 1991; *Observer*, 7 April 1991; *Ittefaq*, 9 April 1991; *Janata*, 12 & 21 April 1991; *Bangla*, 7 April 1991.

54 See discussion of environmental consequences during periods of flooding in Adnan [1991c; 1991d].

55 *Bangla*, 20 November, 12 & 22 December 1990 and 16 & 18 January, 10 February, 9, 16, 20 & 23 March and 9, 14, 20 & 24 April 1991; *Inqilab*, 12 & 15 December 1990 and 10 January, 6, 16 & 20 March 1991; *Millat*, 13 December 1990; *Observer*, 15 & 20 December 1990 and 1 & 14 April 1991; *Ittefaq*, 21 & 22 December 1990 and 1, 9, 14, 22 & 23 March and 6, 8, 10 & 13 April 1991; *Janata*, 27 December 1990 and 17 January, 4, 9, 12 & 30 March and 1, 4, 11 & 15 April 1991; *Sangbad*, 29 December 1990 and 1, 17 & 26 January, 16 & 29 March and 1, 3 & 8 April 1991; *Times*, 8 January 1991; *Bani*, 1 January and 5 March 1991; *Naya Rajniti*, 13 February, 13 & 27 March and 15 April 1991; *Star*, 15 February and 11 March 1991; *Sun*, 19 January 1991; *Sangram*, 2, 13 & 15 March 1991.

56 *Janata*, 15 & 27 December 1990 and 17 January, 1 February and 9 March 1991; *Sangbad*, 17 January, 22 March and 5 April 1991; *Ittefaq*, 28 January and 13 April 1991; *Times*, 14 March 1991.

57 *Bangla*, 11 February 1991; *Janata*, 12 March 1991; *Ittefaq*, 14 March 1991.

58 *Inqilab*, 19 December 1990 and 6 & 16 March, 12 & 13 April 1991; *Bangla*, 22 December 1990 and 9 & 20 March, 14 April 1991; *Sangbad*, 19 January and 22 & 23 March 1991; *Ittefaq*, 23 March, 13 & 11 April 1991; *Janata*, 30 March, 1 & 10 April 1991; *Sun*, 30 March 1991.

59 *Janata*, 12 March 1991; *Holiday*, 26 October 1990.

60 *Janata*, 27 December 1990 and 14 April 1991; *Ittefaq*, 28 January, 28 February, 9 & 30 March 1991; *Sangbad*, 31 January, 17 March & 1 April 1991; *Bani*, 28 February 1991; *Bangla*, 24 April 1991.

61 *Sun*, 11 January 1991; *Ittefaq*, 9 & 30 March 1991; *Sangbad*, 1 April 1991; *Observer*, 1 April 1991.

62 *Bangla*, 11 January 1991; *Sangbad*, 31 January 1991.

63 See Siemelink [1982: 6], DDP [1983: 56] and Guimaraes [1989: 27].

64 *Sangbad*, 17 January & 23 March 1991; *Janata*, 10 April 1991.

65 *Sun*, 11 January 1991; *Janata*, 30 March 1991.

66 *Bangla*, 30 March 1991; *Ittefaq*, 30 October 1990 and 9 April 1991.

67 *Sangbad*, 11 November 1990 and 11 February 1991; *Ittefaq*, 8 December 1990; *Observer*, 6 December 1990; *Bangla*, 17 March 1991, *Inqilab*, 20 February 1991.

68 *Observer*, 6 December 1990. Banu & Shahriar [1990]; *Sun*, 11 January 1991.

69 *Ittefaq*, 8 December 1990; *Sangbad*, 11 February 1991; *Inqilab*, 20 February 1991; *Bangla*, 17 March 1991.

70 Cf. RAS [1990a; 1990b] and Adnan [1991c; 1991d].

71 See discussion in Adnan [1991c; 1991d].

72 This however is not the case with the Brahmaputra-Jamuna, according to Coleman [1969] and preparatory studies carried out for the proposed Jamuna Bridge.

73 The points made here are to be credited to Bruce Currey whose professional knowledge of these matters helped us to clarify and correct some of the more popular theories being propagated by the press.

74 See BWDB [1987] for evidence of widespread embankment breaches.

75 Goswami [1985: 977]. I am indebted to Bruce Currey for making this paper available to me.

76 In 1987-88 and 1989-90, Bangladesh also experienced a number of earthquakes within short intervals. See *Holiday*, 26 October 1991.

77 *Janata*, 27 December 1990 and 12 March 1991; *Inqilab*, 15 & 19 December 1990; *Sun*, 11 & 19 January 1991; *Times*, 29 December 1990; *Ittefaq*, 22 March 1991; *Sangbad*, 1 April 1991; *Observer*, 1 April 1991.

78 *Sun*, 7 February 1991; *Janata*, 12 March 1991.

79 *Janata*, 1 April 1991. See photograph in the Sangbad of 29 March 1991, reproduced in Adnan [1991d: 26].

80 *Bangla*, 18 November 1990 and 16 January 1991; *Ittefaq*, 28 January, 17 February, 22 March and 8 April 1991; *Janata*, 27 December 1990 and 9 March & 1 April 1991; *Sangbad*, 1 April 1991; *Observer*, 11 February and 1 & 14 April 1991; *Inqilab*, 12 & 15 December 1990 and 5 March 1991; *Naya Rajniti*, 15 April 1991.

81 *Janata*, 27 December 1990; *Bani*, 28 February & 10 March 1991; *Ittefaq*, 28 January 1991; *Observer*, 27 December 1990; *Sangbad*, 28 December 1990.

82 Acknowledgements are due to Bruce Currey for this point.

83 *Janata*, 20 November 1990; *Sangbad*, 29 December 1990 and 26 January 1991; *Ittefaq*, 8 March 1991.

84 *Sangbad*, 5 January 1991; *Ittefaq*, 17 November 1990 and 18 January 1991; *Janata*, 15 December 1990 and 2 February 1991.

85 Some of the latter constituted elements of larger FCDI structures. Varied instances are cited by: *Sangbad*, 11 & 21 November 1990 and 9 & 16 February, 29 March, and 26 April 1991; *Sangram*, 4 & 5 March 1991; *Observer*, 11 December 1990; *Ittefaq*, 7 March 1991; *Akota*, 29 March 1991; *Bani*, 13 March 1991.

86 *Sangbad*, 11 November 1990 and 9 February 1991; *Times*, 13 February 1991; *Akota*, 29 March 1991.

87 *Bangla*, 18 November 1990; *Inqilab*, 5 March 1991.

88 *Ittefaq*, 8 December 1990; *Inqilab*, 14 December 1990 and 20 February 1991; *Bani*, 13 March 1991.

89 *Observer*, 11 December 1990; *Ittefaq*, 23 March 1991; *Sangbad*, 20 March 1991.

90 *Ittefaq*, 7 December 1990.

91 *Observer*, 27 December 1990.

92 *Bani*, 11 December 1990; *Ittefaq*, 20 & 23 January 1991; *Sangbad*, 4 & 29 March 1991; *Sangram*, 4 & 5 March 1991.

93 *Janata*, 19 November 1990; *Ittefaq*, 18 January 1991; *Bangla*, 27 November 1990; *Bani*, 10 March 1991.

94 *Sangbad*, 5, 7 & 28 April 1991; *Ittefaq*, 27 December 1990 and 5, 6,10 & 13 April 1991; *Inqilab*, 7 & 26 April 1991; *Janata*, 11 & 15 April 1991.

95 For details of erosion in the wet season, see Adnan [1991c; 1991d] and RAS [1990a; 1990b].

96 *Holiday*, 26 October & 2 November 1990; *Ittefaq*, 24 March 1991.

97 *Observer*, 6 December 1990; *Bani*, 16 December 1990; *Ittefaq*, 30 October 1990; *Holiday*, 2 November 1990; *Sun*, 3 January 1991; *Sangbad*, 5 February & 13 April 1991; *Inqilab*, 20 February 1991; *Bangla*, 17 March 1991.

98 *Bani*, 27 December 1990; *Ittefaq*, 14 April 1991; *Inqilab*, 15 April 1991.

99 *Janata*, 20 November 1990; *Sangbad*, 29 December 1990.

100 *Ittefaq*, 8 March 1991.

101 *Ittefaq*, 6 December 1990; *Sangbad*, 29 December 1990 and 21 January 1991; *Janata*, 1 April 1991; *Star*, 10 March 1991.

102 *Observer*, 10 October 1990.

103 *Natun Katha*, 16 November 1990; *Bangla*, 7 & 16 December 1990 and 11 January, 17 & 19 March 1991; *Sangbad*, 6 & 26 January and 2 February 1991; *Ittefaq*, 7 & 23 January and 17 February 1991; *Inqilab*, 9 November 1990 and 5 March 1991.

104 *Ittefaq*, 7 January and 10 February 1991; *Sangbad*, 13 & 26 January, and 1 & 5 February 1991; *Naya Rajniti*, 30 January 1991; *Observer*, 10 & 23 October 1990 and 9 February 1991; *Star*, 15 February 1991; *Bani*, 2 March 1991; *Inqilab*, 9 November 1990.

105 *Ittefaq*, 8 March & 23 April 1991; *Sangbad*, 15 February & 10 April 1991; *Naya Rajniti*, 27 March 1991.

106 *Ittefaq*, 3 January 1991.

107 *Naya Rajniti*, 16 & 30 January 1991.

108 *Bani*, 26 November 1990 and 9 & 23 March 1991; *Observer*, 11 & 15 December 1990; *Sangbad*, 7 December 1990 and 13 & 31 January, 9 February & 20 March 1991; *Ittefaq*, 7 & 8 December 1990 and 13 February, 8 & 23 March 1991; *Janata*, 13 April 1991; *Sangram*, 11 March 1991.

109 *Sangbad*, 26 May 1990 and 13 April 1991; *Bangla*, 7 December 1990 and 9 March & 2 April 1991; *Ittefaq*, 8 & 10 December 1990 and 7 & 8 January and 4 March 1991.

110 See **Map 5** and discussion in **Section 3** of Adnan [1991e] on Dhaka city's flood protection works.

111 *Naya Rajniti*, 16 January 1991; *Ittefaq*, 18 January 1991; *Observer*, 20 January 1991; *Holiday*, 15 March 1991; *Sangbad*, 28 April 1991; *Bani*, 16 March 1991.

112 *Bani*, 15 March 1991.

113 *Sangbad*, 26 May & 9 December 1990 and 6 & 21 January 1991; *Ittefaq*, 8 December 1990; *Inqilab*, 25 December 1990; *Bani*, 3 January 1991; *Star*, 15 January 1991.

114 *Sangbad*, 9 December 1990. See Adnan [1991c; 1991d] and RAS [1990b] for details of the flood damage and people's response to it in Sirajganj during the monsoon of 1990.

115 *Sangbad*, 6 February 1991. The press report finds the information about an alleged robbery at the stores of the Muhuri Irrigation Project somewhat suspicious, if not deliberately contrived altogether.

116 The material presented below is thus based on the statements and reports published by the newspapers of Bangladesh. We provide a critical review of this information for identifying mechanisms of resource misappropriation, without any necessary endorsement on our part of the specific factual contents of these reports. However, it is significant to note that these allegations have been publicly circulated without objections or protests by the parties concerned appearing in the press in most cases.

117 *Sangbad*, 19 March 1991.

118 *Sangbad*, 15 & 19 March 1991; *Ittefaq*, 23 April 1991.

119 *Sangbad*, 6 April 1991.

120 *Sun*, 1 January 1991; *Ittefaq*, 3 & 18 January and 9 February 1991.

121 *Sangbad*, 2 March 1991.

122 *Sangbad*, 27 December 1990. This was briefly noted in our previous report: RAS [1990b: Appendix E].

123 See report in *Akota, 1 June 1990*, citing the Japanese newspaper, *Shukan Post*, dated 16 March, and 11 & 18 May 1990.

124 *Sangbad*, 27 December 1990.

125 See various press reports in Bangladesh newspapers during May, 1991. See RAS [1992].

126 *Bangla*, 16 November 1990 and 9 March 1991; *Ittefaq*, 6 April 1991; *Janata*, 1 & 10 April 1991; *Sangbad*, 10 & 19 March 1991.

127 *Sangbad*, 19 March 1991; *Bangla*, 9 March 1991; *Janata* , 1 April 1991.

128 *Sangbad*, 19 March 1991.

129 *Naya Rajniti*, 16, 23 & 30 January 1991; *Bangla*, 9 March 1991; *Sangbad*, 19 March 1991; *Janata* , 1 April 1991.

130 *Sangbad*, 15 February 1991; *Ittefaq*, 17 February 1991.

131 *Sangbad*, 21 January 1991. The law on this matter underwent significant change during this period, in a manner which was likely to be to the disadvantage of poor and weak landowners.

132 *Inqilab*, 2 April 1991. Cf. Adnan & Mansoor [1978] and Adnan [1991c].

133 *Inqilab*, 23 December 1990. See photograph.

134 *Bani*, 10 January 1991; *Inqilab*, 10 January 1991; *Sangbad*, 29 December 1990 and 1 January 1991.

135 *Janata*, 22 December 1990; *Ittefaq*, 22 December 1990.

136 *Janata*, 1 April 1991.

137 *Bangla*, 11 January 1991; *Janata*, 9 April 1991; *Sangbad*, 19 March 1991.

138 *Sangbad*, 6 February 1991; *Sangram*, 10 March 1991.

139 *Sangbad*, 23 March 1991; *Sun*, 3 January 1991; *Observer*, 15 December 1990.

140 *Sangbad*, 19 March 1991.

141 Adnan [1991a].

142 *Bangla*, 19 January 1991.

143 *Sangbad*, 12 April 1991.

144 A selection of relevant press clippings (English ones only) is provided in Appendix C of RAS [1991] which may be looked up by the interested reader.

145 These points have been already referenced in the preceding sections.

146 See discussion on the Flood Action Plan in Adnan [1991c; 1991d], and government policies on flood protection measures in general.

147 Most of the national and provincial newspapers listed under References at the back, were scanned. Altogether, 38 editorials were found to be relevant to the discussion at hand. Of these, two were published earlier than November, 1990. Details of these editorials are specifically listed in Adnan [1991e].

148 See assessment of the role of the press in RAS [1990b] and Adnan [1991c; 1991d]. However, unlike the past, there has been a significant increase in public discourses in other fora, including meetings and conferences of concerned professionals, as has been already noted above.

149 *Bangla*, 19 & 21 January, 11 February, 19 March and 2 April 1991; *Sangbad*, 1 April 1991; *Ittefaq*, 17 February 1991; *Inqilab*, 2 March and 20 April 1991; *Janata*, 23 December 1990 and 1 February and 11 April 1991; *Bani*, 11 November 1990 and 25 February 1991.

150 *Sangbad*, 11 November 1990 & 28 April 1991; *Ittefaq*, 23 March 1991.

151 *Sangbad*, 26 May 1990 & 10 April 1991; *Ittefaq*, 23 March 1991; *Janata*, 10 April 1991.

152 *Ittefaq*, 4 March 1991.

153 *Sangbad*, 9 December 1990. See discussion of the near-famine situation obtaining in Sirajganj during the wet season in 1990, and the footdragging of the administration on flood relief in RAS [1990b] and Adnan [1991c; 1991d].

154 See, in particular, *Sangbad*, 5 February 1990. The three-day national conference, on the basis of which this editorial was written, provided a wide diversity of views. The editorial itself agreed largely with the view advocated by BARC [1989].

155 *Ittefaq*, 23 March 1991.

156 See for example the analysis of problems in the following editorials: *Sangbad*, 26 May, 11 November & 9 December 1990 and 17 & 23 March, 1 & 10 April 1991; *Observer*, 31 March 1991; *Ittefaq*, 23 March 1991.

157 *Sangbad*, 16 February 1991.

158 *Ittefaq*, 4 March 1991.

159 *Sangbad*, 11 November 1990; *Ittefaq*, 23 March 1991.

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161 *Sangbad*; 5 February 1991.

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CHAPTER TEN

POPULATION-ENVIRONMENT INTERACTION: A CASE STUDY BANGLADESH

Muhammad Masum

Introduction

Whether a finite environment can support an ever growing population has been intensely debated since the days of Malthus and the above issue came to limelight at the UN Conservation Conference in 1949, when in the opening address, Osborn observed, *"Within the last century startling developments of a worldwide nature have taken place. . . Unquestionably the greatest factor of change is the explosive upsurge in population in virtually all countries resulting in doubling of the world population within the last century. . . (which) has been accompanied. . . by an almost fantastic series of inventions. The consequence has been that the drain upon the Earth's resources has increased not upon a mathematical scale related to population growth, but upon a geometrical scale related to greater numbers of people demanding a greater variety of products from an infinitely more complex industrial system"* (Caldwell 1990).

The 1970s wake up with the publication of *The Population Bomb* which encapsulated what came to be called the neo-Malthusian view. The basic argument was as follows. The world had already become over-populated and the development trends were unsound from an ecological point of view. Population levels had overshot the carrying capacity of the planet so that life could now be sustained only by consuming capital resources, fossil fuels and other non-renewable resources and by poisoning ecological

systems (Ehrlich 1971). *The Limits to Growth* (Meadows *et al.* 1974) published in 1974 went one step further. It argued that as our environment the earth is finite, the growth in human population and spread of industrialization could not continue indefinitely. Modelling on different sets of data and assumptions, it projected the future. Assuming no major changes in physical, economic and social relationships, it predicted the overshooting and collapse of the world system because of a diminishing resource base. Assuming major technological advances such as use of unlimited nuclear energy in place of fossil fuels and enabling lower grade non-renewable materials to be developed economically, the limit to growth appeared in the form of mounting pollution levels leading to widespread environmental degradation, ecological collapse and the consequent failure of food supplies. When it was assumed that strict measures of pollution control would be introduced, the pollution crisis might be averted but only at the cost of food shortage, the limit of agricultural land having already been reached. Relaxing constraint on the availability of cultivable land through universal adoption of the green revolution technology which significantly enhanced land productivity would, however, bring about ecological collapse. Thus, even with appropriate technical advances in the spheres of non-renewable resources, population control and food production, there were limits to growth and only population limitation could possibly make any real impact in averting 'overshoot and collapse.'

The Ultimate Resources (Simon 1981), however, presented a sharply contrasting view arguing that the fundamental resource is people. More people create a larger market for goods and services, stimulating development, innovation and improvement. More people bring more talent and intellect to bear on current problems, thus making their solution more likely. Population growth, therefore, does not pose a permanent threat but, on the contrary, brings with it the very tools needed to overcome obstacles and improve the standard of living. In the short run, he maintains, all resources are limited. Greater use of any resource means pressure on supplies. But the long run phenomenon is a different story (Fernie and Pitkethly, 1985). The standard of living has risen along with the size of the world's population since the beginning of recorded time. And with increases in income and population, have come less severe shortages, lower costs and an increased availability of resources, including a cleaner environment and greater access to natural recreation areas (Simon 1981).

What may be true for the entire world may not, however, be true for a single country, particularly, since not all countries are equally endowed with resources, nor are they at similar stages of development. Moreover, as evidenced by the existence of innumerable artificial barriers to movement of men and materials, it seems that the spirit and goodwill to share global resources reasonably equitably is also yet to emerge.

In Section 2, we propose to develop and discuss a conceptual framework depicting population-environment interactions. In Section 3, we discuss the Bangladesh situation highlighting the above interactions and in Section 4, we record our concluding observations.

Section 2

Population-Environment Interactions

The word 'environment' literally means "*. . .the entire ranges of external influences acting on an organism. . .*" (Encyclopaedia Britannica). In this paper, however, we are concerned with only one segment of environment, i.e. the physical environment and its functions as:

- A source of natural resources (raw material, energy).
- A source of environmental services (life support, recreation, beauty) and
- An assimilator of residuals.

The physical environment may be classified into:

- The 'atmosphere' comprising such elements as air, space, weather and climate.
- The 'hydrosphere' involving water.
- The 'lithosphere' including land and soil, fuel and non-fuel minerals from the land and from the sea and
- 'New energy sources' comprising such non-conventional sources as solar, tidal and atomic energy.

The size, structure and distribution of population are determined by three basic demographic variables—fertility, mortality and migration. The size of the population of a country grows if the rate of fertility exceeds the rate of mortality and/or if there is net migration into the country. There may be

migration within the country as well. In developing countries, one usually notices, migration of population from rural to urban areas which is known as urbanization.

Population plays a dual role—as a producer and also as a consumer. While the entire population consumes, only a part i.e. the employed labour force produces. The structure i.e. the age distribution of the population determines the size of the potential labour force, (number in the productive age-group) and also the dependency ratio, defined as the number of dependents for every 100 persons in the productive age-group. Level and nature of economic activity within a country determines the size of the employed labour force whose productivity and income are determined by their levels of human resource development i.e. skill composition, the level of technology and other factors in the production process.

Besides quantitative dimensions such as size, structure and distribution, population has some qualitative aspects as well e.g. its educational and health status, and most important of all, its level of absolute (percentage of population below poverty line) and relative poverty (pattern of income distribution) which have significant bearing on the welfare and quality of life of the population.

Let us us now examine the population-environment interactions as depicted in Figure 1.

As mentioned earlier, the entire population consumes and the pattern of consumption is significantly influenced by the pattern of income distribution. Both the consumption and investment demands of the population are met by two major means, one, directly from nature and the other, through the production process where the employed labour force interact with resources including those provided by nature such as raw materials and energy and technology. Both the above means affect physical environment quantitatively and qualitatively. Environment also acts as a repository for the wastes generated by consumption and production.

Impact of Population Growth on Environment

Consumption needs of a growing population exert pressure on environment in a number of ways. For meeting the additional requirement of food, either extensive or intensive cultivation or both are taken recourse to. In the former case, marginal land is brought under cultivation which leads to

Figure 1

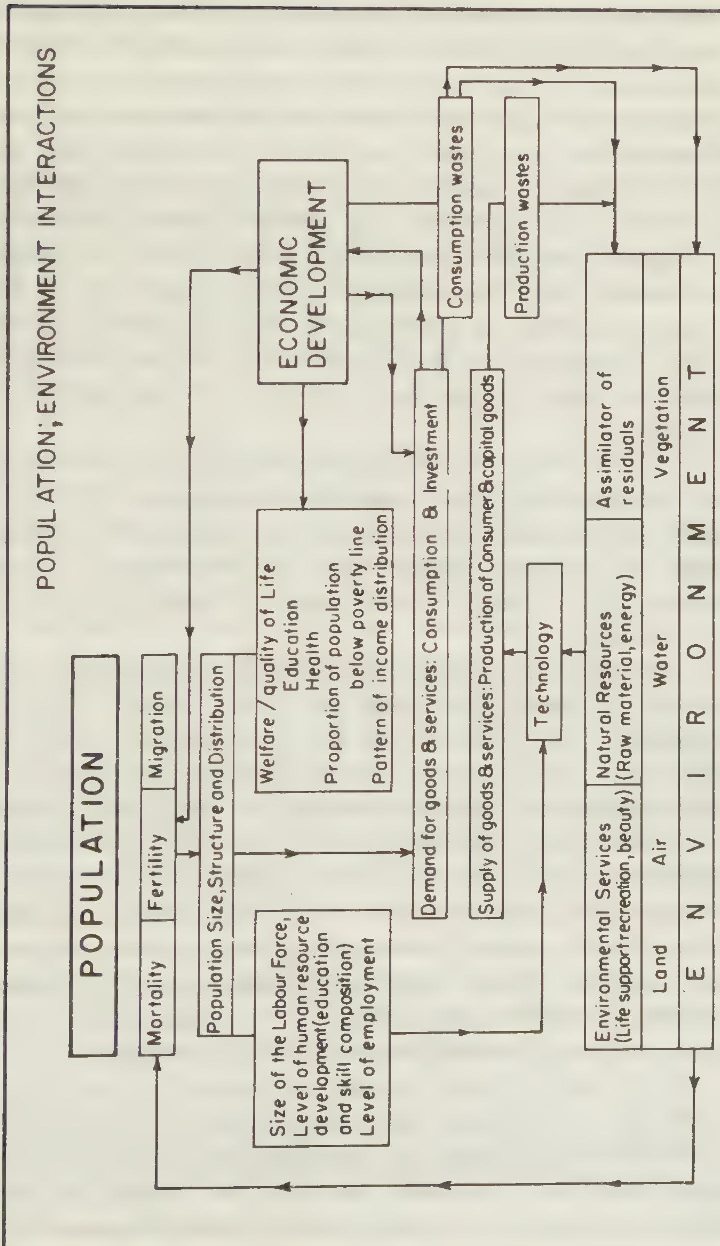

Fig-1

erosion and loss of soil fertility. Quite often, the addition to cropped acreage is made by clearing forests. Deforestation in turn, causes soil erosion, siltation and flooding in river basins, changes in micro-climate and loss of habitat. When cultivation extends to lowlying areas, the traditional habitat of fish is encroached upon. Shrinkage of pasture land adversely affects both quantity and quality of livestock resources. In the latter case, i.e. when intensive cultivation is practised on the same or shrinking agricultural land (due to increased demand generated for housing and construction of social and physical infrastructural facilities by the additional population, the following problems are normally encountered: increased run-off and ecological hazards from chemical fertilizers and pesticides, reduced genetic diversity in the plant population, water logging and salinity from irrigation.

In order to absorb the growing labour force in productive employment, there hardly exists any option other than industrialization. This, however, is usually accompanied by rapid urbanization putting unbearable pressure on an already over-burdened system, particularly, water supply and sewerage. Incidence of air pollution is also more due to an increasing number of buses, trucks and cars.

Increased industrial production for meeting consumption and investment demands of a growing population uses up an increasing amount of raw materials including minerals and energy. In the process, this not only depletes the country's natural resource base, but also adds to industrial pollution and thereby degrades the environment of the country concerned.

Environmental impacts of a growing population are much sharper in a developing country as the pursuit of development—an improvement in the standard of living and quality of life of the people, exerts greater pressure on environmental resources. Growth presupposes investment. Higher investment, therefore, obviously implies a speedier depletion of environmental resources. Development projects implemented without proper environmental impact assessment often cause major environmental hazards.

When a country experiences inequitable growth i.e. when the fruits of growth are not equitably shared and skewness of income distribution accentuates resource depletion, environmental degradation proceeds at a quicker pace. On the one hand, production and consumption patterns get distorted in favour of high energy intensive products demanded by the rich; on the other hand, the poor and the unemployed are forced to eke out their

living from open access natural resources, such as open water fishery, resulting in depletion of stock through over-exploitation of such resources. Besides, poverty is universally recognized as the greatest polluter.

Impact of Environmental Change on Population

Environmental degradation may have feedback effects on population by contributing to poorer physical and mental health and by interfering with man's productive capacity. It may also lead to migration as people often try to escape from areas experiencing environmental degradation. Natural disasters often cause considerable loss of life.

Demographic variables are influenced by environment in a number of ways. Pollution of air and water directly influence morbidity, thereby mortality and through it, fertility. Substances such as sulphur dioxide, nitrogen oxide, carbon monoxide, hydro-carbons etc. are harmful to health. Polluted water cause a number of diseases. Organic solid wastes stimulate the growth of flies, mosquitoes and other insects which spread a number of diseases. Environmental problems often lead to inter-group conflicts and sometimes war between countries with the subsequent impact on mortality.

The most important linkage between environment and population, however, seems to be that the reduction of material resources per capita which impairs the human productive capacity and thereby the volume of consumption as a result of environmental degradation, usually causes psychic stress influencing morbidity and mortality. Deteriorating living space and material standard of living may result in fertility reduction. Higher mortality rate, particularly, of infants due to environmental degradation, on the other hand, may lead to increase in the fertility rate as an insurance against possible future loss of children.

Section 3

Population-Environment Interactions in Bangladesh

Bangladesh, the most densely populated country in the world which is also experiencing a rapid rate of population growth provides a unique setting for examining population-environment linkages described in the previous section.

Bangladesh has a population of 108 million (1991 Census), growing at the rate of 2.17 per cent per annum. Population density it 782 persons per square kilometre. About 82 per cent of the population live in rural areas.

It took nearly 80 years for Bangladesh's population to double in size, from 22.8 million in 1872 (when the first census was conducted) to 44.2 million in 1951. Since then, the population has grown fast. Inter-censal growth rates in the current century, 1901-1991 are presented in Table 1.

Table 1

Population and Inter-censal Growth Rates 1901-1991

Census Year		Population* (in million)	Growth Rates
1901	March 1	28.9	—
1911	March 10	31.6	0.94
1921	March 18	33.3	0.60
1931	February 28	35.6	0.74
1941	March 14	42.0	1.70
1951	March 1	44.2	0.50
1961	February 1	55.2	2.26
1974	March 18	76.4	2.48
1981	March 5	89.9	2.32
1991	March 11	103.0	2.17

(Bangladesh Bureau of Statistics 1991).

*Adjusted Figures.

Recent studies indicate that the country in 1990 had a Crude Birth Rate (CBR) of 35.2 and a Crude Death Rate (CDR) of 13.6 per thousand per annum. The comparable figures in 1985 were 39.0 and 15.0 respectively. The decline in fertility can possibly be explained by extended coverage of the immunization and mother and child health (MCH) programmes. Infant mortality rate also came down from 123 in 1985 to 110 per thousand live births in 1989. Life expectancy at birth also improved to 53.0 years in 1991.

Despite recent declining trends in the fertility rate, because of the tremendous growth potential built into the age structure of Bangladesh's population as a consequence of past high fertility; population under 15 years account for 42 per cent of the total population and females within the reproductive age bracket (15-49) account for 48 per cent of the total female population), the country's population is expected to grow at a fairly high rate for a long time to come. Table 2 presents the projected population, CBR, CDR and the rate of natural increase (RNI) of Bangladesh, up to the year, 2010 when it may reach a level of 148.4 million (Rahman 1991). Population Reference Bureau, however, projects a much higher figure, 176.6 million for the same year 2010 (Population Reference Bureau 1991).

Table 2

Projected Population Birth Rate (CBR), Crude Death Rate (CDR) and Rate of Natural Increase (RNI) 1990-2010

Year	Population (in million)	CBR (in thousand)	CDR (in thousand)	RNI (in thousand)
1991	110.5	34.97	13.31	21.66
1992	112.9	33.38	13.03	20.35
1993	115.2	31.65	12.60	19.05
1994	117.4	30.51	12.24	18.27
1995	119.6	29.31	11.89	17.42
1996	121.7	28.14	11.63	16.51
1997	123.7	27.21	11.34	15.87
1998	125.7	26.51	11.08	15.43
1999	127.7	25.89	10.85	15.04
2000	129.6	25.49	10.67	14.82
2005	139.3	23.56	10.04	13.52
2010	148.4	20.06	09.49	10.57

(Rahman 1991)

Although, Bangladesh has still a predominantly rural economy, the urban population accounting for only 18 per cent of the total population; given the past trend in urbanization, according to one projection by the Planning Commission, urban population is expected to rise to 29.5 per cent and 35 per cent of the total population in years 2000 and 2010 respectively (Task Force Report 1991).

Size of the labour force of Bangladesh was estimated to be 50.7 million in 1989 whereas it was 30.9 million in 1985-1986. The sharp increase, however, is more an outcome of changes in definition recognising certain activities usually undertaken by women in agricultural household economic activities, previously not recognised as such. The rural-urban breakup of the labour force was 45.0 million rural and 5.7 million urban. Of the 50 million employed labour force, 32.6 million were engaged in agriculture, 7 million in manufacturing and the rest in other economic sectors. Rate of open unemployment as recorded was extremely low, only 1.20 per cent (BBS 1991). The employed population, however, suffered from a high degree of underemployment, estimated around one-third of the available labour time and extremely low productivity because of a low level of technology in most activities and a lack of resources to work with. This primarily accounts for the prevalence of widespread poverty in Bangladesh.

According to the Bangladesh Household Expenditure Survey, in 1985-1986, 51.2 million people (44.2 million rural and 7 million urban) remained below the poverty line (defined as income level needed for intake of 2122 cals/day/person). They accounted for 51 per cent and 56 per cent of the urban population respectively. Among them, 21.5 million (19.1 million rural and 2.4 million urban) lived in extreme poverty (with a consumption level of less than 1805 cals/day/ person) and they accounted for 22 per cent and 19 per cent of the total rural and urban population respectively (BSS 1991).

Distribution of household income in Bangladesh is also highly unequal. Movement of Gini ratio which measures the degree of inequality showed an increasing trend during the 1980s arising from 0.337 in 1981/1982 to 0.362 in 1985/1986 (Rahman 1989).

In terms of human development indices as well, Bangladesh's population does not perform any better. Adult literacy rate, in 1985, was only 32 per cent, mean years of schooling only 2.0 in 1980) and the combined primary and secondary enrolment ratio was 41 per cent in 1987. Only 45 per cent of

the population had access to health services in 1985-1987 (UNDP 1991). Percentage of population with access to safe water stands at 56 per cent (53.0 per cent in rural and 76.3 per cent in urban areas), to sanitary/water sealed latrines at 1 per cent (negligible in rural and 10 per cent in urban areas). Percentage of people living in *pucca*/semi *pucca* houses stands at 16.6 per cent (13.5 per cent and 36.4 per cent in rural and urban areas respectively) (Task Force Report 1991).

Broadly outlining Bangladesh's population spectrum, its size, structure, distribution and various socio-economic characteristics, we are now in a position to examine the country's population-resources balance, changes over time due to various economic activities of production and consumption by its population and also their impact on the environment. Changes in population-resources balance, production, consumption and import of selected commodities in Bangladesh over 1975-1988 are presented in Table 3.

Although arable land as a percentage of total land area, 73 per cent in Bangladesh is one of the highest in the world; given its extremely high density of population, crop land per capita is barely 0.08 hectare, possibly one of the lowest in the world. Agriculture being the major employing sector, accounting for 65 per cent of the employed labour force, the limited crop land has the responsibility to produce, not only enough food to feed the entire nation, which is growing at an alarming rate, but also to generate adequate employment to ensure access to the same. In an attempt to discharge the above twin responsibilities, crop land in Bangladesh expanded at an annual rate of 0.07 per cent over the 1965-1985 period (UNDP 1991) and more recently, over 1975-1977 and 1985-1987, by 0.3 per cent but only at the cost of forest and woodland which declined by 3.4 per cent over the same period (Table 3).

More and more lowlying areas, the flood plains, the traditional habitat of fish were also brought under cultivation by implementing a number of flood control and drainage projects. When limits to extensive cultivation were reached, intensive cultivation was practised. Irrigated land as a percentage of total crop land increased from 15 per cent in 1975-1977 to 23 per cent in 1985-1987, average fertilizer use per hectare per annum increased from 29 kgs. to 68 kgs. and the use of insecticides also substantially increased (Table 3). However agricultural production failed to keep pace with the growing population not only in terms of providing food but also in

Table 3

CHANGES IN POPULATION-RESOURCES BALANCE, PRODUCTION, CONSUMPTION AND IMPORT OF SELECTED COMMODITIES IN BANGLADESH OVER TIME

1. LAND AREA AND USE, 1975-87

Land Area (000 hectares)	Population Density (Per 1000 hectares)	LAND USE: Crop Land (000ha) 1985-87	Percentage Change since 1975-77	Permanent Pasture (000ha) 1985-87	Percentage Change since 1975-77	Forest (000ha) 1985-87	Wood Land Percentage Change since 1975-77
13,391	8,404	9,154	0.3	600	0·0	2126	(-3·4)

2. FOOD AND AGRICULTURAL PRODUCTION 1976-88

Index of agricultural production 1979-81=100: Total 1976-78	Total 1986-88	Per capita 1976-78	Per capita 1986-88	Index of Food Production 1979-81=100: Total 1976-78	Total 1986-88	Per capita 1976-78	Per capita 1986-88
94	111	103	92	94	111	102	92

3. AGRICULTURAL INPUTS

Crop Land Hectares par capita 1989	Irrigated Land as a % of crop land 1975-77	Irrigated Land as a % of crop land 1985-87	Average annual fertilizer use kg. per hectare of crop land 1975-77	Average annual fertilizer use kg. per hectare of crop land 1985-87	Average annual use of pesticide metric ton active ingredient 1982-84
0·08	15	23	29	68	234

4. LIVESTOCK POPULATION

CATTLE: Annual average (000) 1986-88	CATTLE: % Change since 1976-78	Cattle per capita 1986-88	SHEEP AND GOATS: Annual average (000) 1986-88	SHEEP AND GOATS: % Change since 1976-78	CHICKEN: Annual average (millions) 1986-88	CHICKEN: % Change since 1976-78
22,568	-12	0·2	11,726	3	76	35

5. FOOD TRADE AND AID (1975-87)

Average annual net trade (import) in food: CEREALS (000 metric tons) 1975-77	CEREALS 1985-87	OILS (metric tons) 1975-77	OILS 1985-87	PULSES (metric tons) 1975-77	PULSES 1985-87	Average annual receipts of food aid: CEREALS (000 metric tons) 1975-77	CEREALS 1985-87	OILS (kg. per capita) 1975-77	OILS (kg. per capita) 1985-87	OILS (metric tons) 1985-87
1544	1864	89,212	320,734	801	13,062	1155	1463	15	14	23,305

6. WOOD PRODUCTION

Round Wood Production (000 M^3): Total 1985-87	Total % Change since 1975-77	Fuel and Charcoal 1985-87	Fuel and Charcoal % Change since 1975-77	Industrial Round wood 1985-87	Industrial Round wood % Change since 1975-77	Paper Production (000 metric tons) 1985-87	Paper Production % Change since 1975-77
27,849	30	26,999	32	849	(-15)	111	113

7. PRODUCTION AND CONSUMPTION OF ENERGY

Production (petajoules): Total 1987	Total % Change since 1977	Solid 1987	Solid % Change since 1977	Liquid 1987	Liquid % Change since 1977	Gas 1987	Gas % Change since 1977	Total (petajoules) 1987	% since 1977	Per capita (gigajoules) 1987	% Change since 1977
144	324	0	X	5	X	137	328	202	138	2	100

(World Resource Institute 1990)

generating adequate employment. In the process, it resulted in environmental degradation in terms of reduced forest land, depletion of fish stock, decline in livestock resources and deterioration in soil quality.

Although total food production index increased from 94 in 1976-1978 (1979-1981=100) to 111 in 1986-1988, in per capita terms, it declined from 102 to 92 over the same period. Dependence on imports of food grain and food aid, therefore, increased. As increased food grain production could be achieved only at the expense of cropped acreage under pulses and oil seeds, imports of the same substantially increased (Table 3).

Surplus labour in agriculture increased from 28.14 per cent in 1960 to 32.47 per cent in 1983-1984 as growth in agricultural output accompanied by low employment elasticity failed to keep pace with growth in the agricultural labour force (Masum 1989).

Bangladesh has one of the highest livestock densities in the world and with the existing land, it is difficult to produce enough feed and fodder. Production of modern short-stemmed rice replacing local varieties has caused deterioration in quality and reduction in quantity of fodder. Moreover, due to current acute shortage of fuelwood in Bangladesh due to reduction in forest area, increasingly larger quantities of crop residue and dung are used as fuel resulting in reduced feed and fodder for the livestock and also diversion of valuable nutrients and organic matter from soil leading to its further deterioration.

Recent investigation by FAO reveals that there exists a general trend towards declining land productivity in Bangladesh caused mainly by intensive cropping through indiscriminate use of fertilizers, continued use of irrigation water and total removal of biomass from the agricultural fields (Task Force Report 1991).

Due to increasing pressure of a fast growing population on limited land and operation of the laws of inheritance, farms gradually are becoming smaller in size. Productivity gains attained through technological improvements have failed to offset erosion of the resource base. As a result, farms are increasingly becoming non-viable. The process of landlessness is further accentuated by floods, river erosion and other natural calamities. Landless households, defined as those having a maximum cultivated area of up to 0·2 hectares increased from 50.1 per cent in 1978 to 56.5 per cent in 1984.

Pushed out of crop agriculture, increasing number of the rural poor took up non-agricultural activities in trade, transportation and rural industries.

Some resorted to open water fishing which was already under pressure due to construction of a large number of flood control, drainage and irrigation (FCDI) projects. Over-exploitation of an already depleted stock on a shrinking fish habitat caused serious erosion in fishery resources of Bangladesh and also of its biodiversity. Not only do the flood protection embankments interfere with natural recruitment and dispersal of inland fish stock over the flood plain, they also disrupt fish and fresh water shrimp migratory patterns. Irrigation barrages in rivers similarly disrupt migratory movement of fish and shrimp. In addition, the increased use of low-lift pumps for irrigation and drainage of surface water contributes to a decline in the fish stock (USAID 1990).

Having discussed part of the environmental consequences of production of food for a growing population, let us now turn to other items included in the consumption basket of the people of Bangladesh. Some of the manufactured items are produced within the country, others are imported. Industry, though still a small sector, accounting for about 10 per cent of the GDP, primarily being concentrated in a few urban areas, causes considerable industrial pollution. 144 industries, operating in the 8 industrial zones of Chittagong discharge their untreated wastes (including toxic wastes) directly into the Karnaphuli river. Large moats of polluted water surround tanneries and textile mills which are barely separated from crop fields (USAID 1990). For footing the growing import bill, Bangladesh has already started exporting natural gas after converting the same into fertilizer, thus depleting its only significant energy resource.

The domestic sector accounts for 65 per cent of the total energy use of which 73 per cent is drawn from biomass. Even 70 per cent of energy used in the industrial sector comes from biomass. Over 1975-1977 to 1985-1987 annual wood production for fuel and charcoal increased by 32 per cent primarily to meet the increase in demand due to population growth. Over the same period, production of paper also increased by 113 per cent. Forest resources, as a result, were put to severe strain, leading to substantial deforestation.

Although urban population accounts for only 18 per cent of the total population of Bangladesh, over 40 per cent is found in 3 metropolitan cities only; Dhaka 26 per cent, Chittagong 10 per cent and Khulna 5 per cent. Natural rate of increase accompanied by a high level of rural-urban migration on account of growing landlessness has led to increased population pressure,

particularly, on Dhaka. Due to sharp increase in housing cost, the middle class is pushed to marginally serviced areas at the fringe of the city. Housing shortages forces urban dwellers to live in high density units, often without proper facilities such as piped water, sewerage and garbage removal. The incidence of disease is, therefore, high amongst the slum dwellers. The infant mortality in one central slum area in Dhaka was found to be as high as 152 per thousand live births, much higher than the national average (USAID 1990). Water supplies are unable to keep pace with the growing demand and are regularly disrupted by lowering of the ground water level in the dry season. The sewerage system is also under heavy strain. Due to increased volume of motorised traffic, air pollution has also increased. The quality of life for urban dwellers, particularly, the poor, has consistently deteriorated with growth of the urban population.

Increased demand for construction materials for urban housing has led to the conversion of nearby agricultural lands into brick fields. Forest resources and fisheries in and around the city are also over-exploited and filling of water-bodies to meet the growing housing needs lead to destruction of fish habitats. The overall impact of urbanization on the environment in Bangladesh is thus a negative one.

Section 4

Concluding Observations

High growth rate of an already vast population has thus saddled Bangladesh with considerable environmental problems. Even for meeting the consumption demands of a growing population at the current pitiably low standard of living (per capita income in Bangladesh was US $180 in 1989) one of the lowest in the world and it had grown at 0.4 per cent per annum over 1965-1989 (World Bank 1991), most of the environmental resources were put to severe strain. It would, however, be erroneous to put the entire blame of environmental degradation in Bangladesh to population growth alone. Much of it resulted from market and policy failures.

"The prevailing economic structure and policy framework leave many resources outside the domain of the market—unowned, unpriced and unaccounted for. More often than not, their excessive use and destruction are effectively subsidized, despite growing scarcity and rising social cost. This

results in an incentive structure that induces people to maximize profits not by being efficient and innovative but by appropriating common property resources. The cost of increasing scarcity is diluted through subsidies paid for by the general public, while the cost of ultimate depletion is borne by the poor who lack alternatives and by future generations whose interests are sacrificed for short-term political expediency. . .policy and market failures are rarely identified as root causes of environmental degradation. . .It is not population growth or density per se that leads to forest encroachment. Rather, it is the failure to provide adequate employment opportunities. . .It is because of policy and market failures that population, resource exports and foreign investment, amongst other factors become proximate cause of environmental degradation (ADB 1991)."

Public policies in the form of under-priced forest products sold to industries led to their inefficient use and thus directly contributed to deforestation in Bangladesh. Similarly, implementation of FCDI projects without proper environmental impact assessment led to degradation of fisheries resources. Again, failure to generate adequate employment opportunities has forced the poor and the unemployed, in their bid to meet their survival needs, to resort to over-exploitation of common property resources such as open water fishery.

Poverty is regarded as one of the greatest threats to environment and the poor are the worst victims of environmental degradation. The widespread poverty in Bangladesh can best be addressed by creating adequate employment opportunities. Employment not only contributes to production but also gives the employed an access to the same. Agriculture, however, has limited absorptive capacity. It can provide productive employment at best to one third of the increase in labour force. The remaining two-thirds, therefore, will have to find employment in the non-agricultural sector, particularly in industries. As industrialization and urbanization usually go had in hand, it is not difficult to foresee an increase in industrial pollution and further deterioration in the environment of the urban and surrounding rural areas, unless an appropriate policy framework is developed and adopted.

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CHAPTER ELEVEN

WOMEN, POVERTY AND THE ENVIRONMENT

Raana Haider

> When resources are stretched thin, it is women, the most marginalized in the first place, who suffer first and most. Women have the smallest share of the resources pie of the world; when the pie shrinks, women's losses are greatest.
>
> Women in the World (Seager and Olson 1986).

> Hunger and poverty are more women issues. Women experience hunger and poverty in much more intense ways than that experienced by men. Women have to stay at 'home' and manage the family with virtually nothing to manage with. When there is nothing to eat, husbands prefer to stay away from 'home' to avoid facing the immediate crisis. Mother cannot avoid facing it. She practically looks for ways to feed the children. It is she who has to invent the last survival manoeuvre.
>
> Mohammad Yunus, Grameen Bank, Bangladesh.

Environment of Poverty

As we approach the year 2000, rural Bangladesh, which contains 85 per cent of Bangladesh's 113 million people, is under-going a process of increasing pauperization plus polarization compounded by an increasing feminization of the resulting poor. Not only are more people becoming poor but the rich are becoming richer and the poor poorer. In this process, there is reason to believe that poverty, too, has a gender bias—in that, it is the women of

Bangladesh who are becoming poorer. They are caught up in a situation of varying degrees of dependency, powerlessness, vulnerability and inequality.

Natural Disasters

The close frequency of events and the extent of devastation caused by the highly visible 1988 Floods and 1991 Cyclone brought into focus the impact of natural disasters on environment and development. Natural disasters are events induced by natural physical processes. These include:

- River flooding, caused by rainfall, melting snow, dam failure, ice jams, mud flows etc.
- Coastal flooding, caused respectively by seismic activities and tropical cyclones.
- High winds, caused by tropical cyclones, typhoons, hurricanes and tornadoes.
- Earthquakes of tectonic or volcanic origin.
- Slides, slips and avalanche of land, rock or snow.
- Drought (UN 1976).

Such extreme natural phenomena are not in themselves disasters. A disaster occurs when one or more of these phenomena strike a human settlement or an area of cultivation causing disruption of the human ecology that exceeds the capacity of the community to function normally (Lechat 1990). The total loss due to the April 1991 Cyclone in Bangladesh has been estimated at US $2.4 billion.

The economic performance of Bangladesh in the last three years has been dominated by the impact of natural phenomena. Even if the economy was able to sustain a growth rate of around 3.5 per cent, it would require nearly six years to recover from the direct and indirect losses caused by Cyclone 1991 (United Nations 1991).

The loss of human lives in natural catastrophes, such as floods and cyclones, with the exception of drought, is instant and direct. They die a quick death. According to the Government of Bangladesh, some 138,000 people are estimated to have died in the 1991 Cyclone. What of the survivors? The effects of the devastation to the ecosystem are often less visible; of a long-term nature and irreversible. The impact of disasters on

water, soil, crops, trees, vegetation, biomass and energy sources, livestock, poultry, wildlife, fisheries, water sources and infrastructures, is such, that the continued survival of the immediate survivors is in question. One undermines the other and damages to the ecosystem can threaten the very survival of human life and its support system (Haider 1991b).

Disasters have also become more and more destructive as they affect larger concentrations of people. Bangladesh's density of population now stands at 750 persons per sq. km., the highest in the world; a situation well-illustrated in Figure 1.

The map shows different countries, in proportion to their population density. Thus, the volume represents total population. It does not show a direct relation between population density and standard of living. Bangladesh and Holland are among the countries with greatest density and they have, in addition, similar geography, with lowlands which are easily flooded, on the deltas of the rivers, Ganges and Rhine respectively. Yet, while Bangladesh is among the world's 20 poorest countries, Holland is one of the richest 20 (Third World Guide 1991/1992).

Natural disasters—floods, cyclones, tornadoes and thunderstorms have, always, occurred in the Bay of Bengal. The particular geomorphology, the Himalayas lying to the north and the funnel shaped coast touching the Bay of Bengal in the south, creates an ideal breeding ground for tropical cyclones and other natural disasters (Choudhury 1991). However, the impact of these natural events has been exacerbated by considerable over-exploitation of common resources such as land, water, forests, fisheries, wildlife and plantlife.

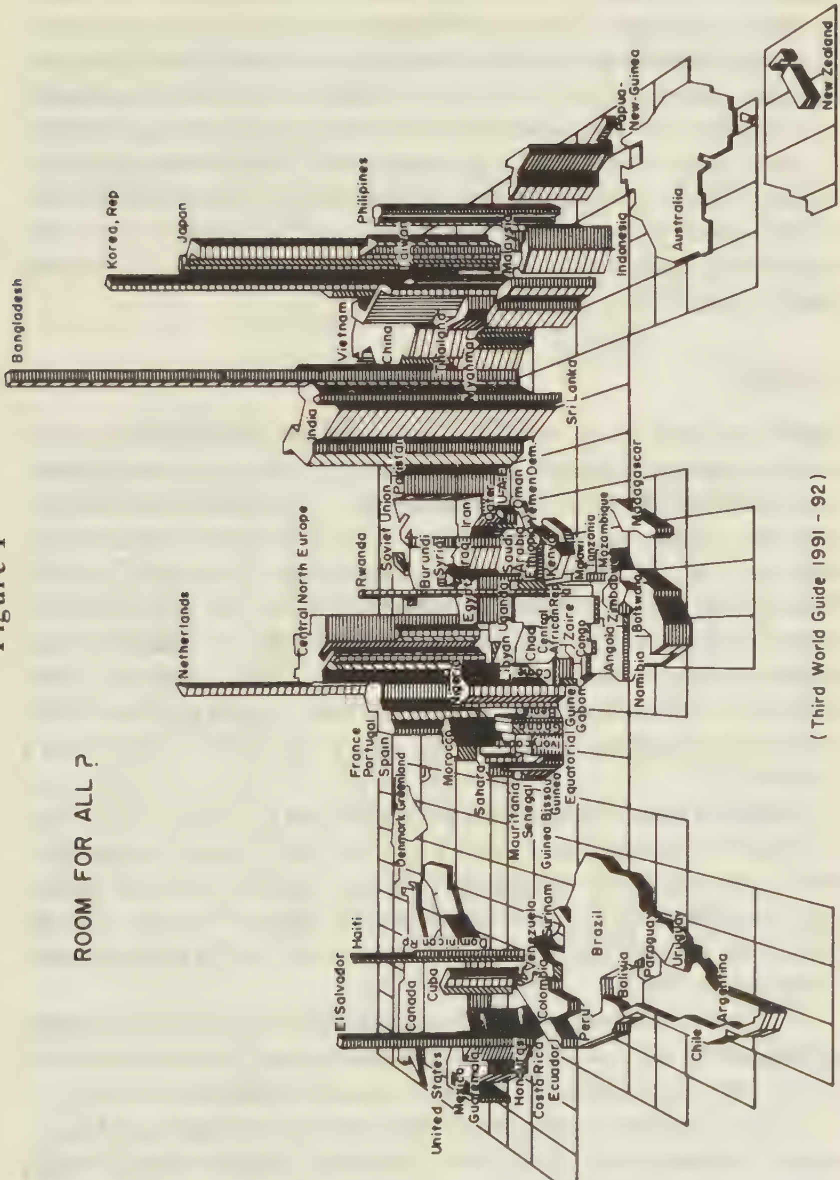
According to (Shiva 1988), damage to nature's intrinsic regenerative capacity is impaired not by over-exploitation of a particular resource, but indirectly, by damage caused to other related natural resources through ecological processes. Thus the excessive felling of trees in the catchment areas of streams and rivers destroys not only forest resources, but also renewable supplies of water, through hydrological destabilisation. The cumulative effect is extensive environmental degradation.

Environmental Refugees

For every victim of natural disasters in Bangladesh, there is an environmental disaster to match—siltation, water-logging, erosion, deforestation, pollution and other manifestations of man's over-use and depletion of the

Figure 1

ROOM FOR ALL ?



(Third World Guide 1991 - 92)

natural resource base. This in turn produces a displacement creating environmental refugees (Jacobson 1988). Environmental refugees in Bangladesh are pre-dominantly landless people who are sliding into a marginal existence and are caught up in a cycle of poverty. The accelerating struggle for renewable and non-renewable natural resources, the spiraling population (2.6 growth rate) and devastating natural events have created a situation whereby economic deprivation and environmental degradation reinforce one another to form a maelstrom—a downward spiral that threatens to pull even more into its grasp; a condition also known as the poverty cycle or poverty trap (Durning 1989).

Poverty

With a per capita income of US $ 170, Bangladesh, tragically comes close to fit the bill of absolute poverty as defined by Robert McNamara, former President of the World Bank. A condition of life so limited by malnutrition, illiteracy, disease, squalid surroundings, high infant mortality and low life expectancy as to be beneath any reasonable definition of human decency. Poverty is the number one disaster in Bangladesh. One can see devastations caused by floods or cyclones. But one can hardly see the casualties of the invisible disaster called poverty (Rahman A. 1990). This is a view supported by Mohammad Yunus of Grameen Bank. Natural disasters–floods, cyclones and earthquakes are not the only disasters. Poverty is also a disaster.

Eighty per cent of Bangladesh's population, live below the poverty line. The distribution of income shows that the top 20 per cent of the population take 40 per cent of the national income while the bottom 20 per cent of population take only 7 per cent of the national income. Over the years, the income distribution has become skewed in favour of the higher income group (Jansen 1990).

Bangladesh also exhibits a highly skewed distribution in land ownership, since some 60 per cent are functionally landless and about 10 per cent of households own 40 per cent of the land (Jahan 1991 and Siddiqui 1992).

Table 1 presents an estimation of the rural poverty line based on the poverty line expenditure on food and basic other non-food needs. It shows the amount of income required to stay above the poverty line; Tk. 1150 in 1973-1974 *vis-a-vis* Tk. 4340 in 1988-1989.

Table 1

Estimation of the Rural Poverty Line

	Per Capita Minimum Daily Requirements		Rural Consumer Prices (Tk/Kg)				
	(Calorie)	(Gm.)	1973-1974	1981-1982	1983-1984	19851986	1988-1989
Rice	1386	397	2.82	5.29	7.52	8.00	10.01
Wheat	139	40	1.64	3.77	5.42	6.11	7.36
Pulses	153	40	3.55	9.48	7.48	13.11	16.62
Milk (Cow)	39	58	1.72	4.70	6.66	8.92	9.95
Oil (Mustard)	180	20	16.72	29.20	37.08	41.71	40.30
Meat (Beef)	14	12	5.88	16.93	23.88	34.97	36.44
Fish	51	48	5.18	9.88	18.31	22.74	23.21
Potato	26	27	2.58	2.61	3.27	4.17	6.69
Other Vegetables	36	150	1.11	1.53	3.04	3.34	4.33
Sugar (Gur)	82	20	3.76	7.23	9.71	11.57	14.73
Fruits (Banana)	6	20	1.57	3.98	5.42	7.40	9.21
Total (Calorie/gm)	**2112**	**832**					

Table 1 (Continued)

	Per Capita Minimum Daily Requirements Rural Consumer Prices (Tk/Kg)						
	(Calorie)	(Gm.)	1973-1974	1981-1982	1983-1984	19851986	1988-1989
Poverty line expenditure on food (Taka per day)			2.42	4.69	6.64	7.80	9.15
Basic non-food needs (at 30% of expenditure on food (Taka per day)			0.73	1.41	1.99	2.34	2.74
Poverty line (Taka per day)			3.15	6.10	8.63	10.14	11.89
Poverty line (Taka per year)			1150	2227	3150	3701	4340

(Task Force Report 1991)

Options

Some environmental refugees migrate to other rural areas in search of agricultural wage labour. Availability of employment, in the agricultural sector, is gradually declining and has now reached saturation point. Only another 2,00,000 labour force can be absorbed in farming by the year 2000, if the agricultural sector can be developed and diversified (Mahmud 1991). The limited rural wage market is also affected by: unsustainable land, a shifting rural economy; such as agricultural land being converted to shrimp farming or mono-cropping, usually rice and the availability of unpaid family labour, usually women; factors which deter rural-to-rural out-migration.

Competition for scarce land and other natural resources drives others to cultivate high-risk marginal lands where they eke out a living on *chars*, land bars of silt and sand in the middle of the Bengal delta, a metre or two above sea level. A large number of fishermen fell victim to Cyclone 1991, since many of them inhabited the low-lying coastal areas and off-shore islands. It has been found that every newly formed island is being occupied almost with brute force because it satisfies land hunger (Pereira 1991).

The accelerating urban population, some 27 million in 1990 versus 13 million in 1981 is testimony to the burgeoning urban population in Bangladesh. The push factor in the rural areas pulls the landless environmental refugees, with little education and no applicable skill or trade, to the fringes of the urban economy. An acute unemployment problem is to be further aggravated by the year 2000, as an additional 10 million labour force is added to the existing 30.4 million (Mahmud 1991). Unless the rural economy provides alternative benefits, the trek to the cities will increase from a considerable trickle into a tidal flow.

In search of livelihood, the displaced landless are forced to relocate and seek a variety of employment. Agricultural wage labour in another rural area, fishing in coastal areas and construction work or rickshaw driving in an urban area can become the employment career of a landless peasant. For the displaced woman, the options are more limited but economic pressure undermines the social barriers.

Seasonality of Employment Prospects

Since Bangladesh is an agrarian economy, the availability of agricultural wage labour for the landless is dependent on the timing of crop cultivation.

Linked to crop production is the climatic factor, monsoon, which also has considerable impact on the incidence of disease and overall quality of life. According to (Haider 1991a), maximum agricultural activities and, thereby, almost daily employment opportunities occur in December to February with the harvesting of *aman* crop and sowing of *boro* and *rabi* crops. Peak wages are available and a small cash surplus may even be possible. The price of rice is low and the prevalence of disease is at a minimum. The quality of life may be said to be at the optimal level.

The pre-monsoon dry months of March to May produce little agricultural activities, limited employment prospects, low wages and increased incidence of diarrhoeal diseases due to stagnant and contaminated surface water.

During the monsoon months of June to August, agricultural activities are at an ebb. Diarrhoeal diseases occur less frequently since the rains flush out the surface water.

The post-monsoon months of September to November produce minimum agricultural labour prospects and lowest wages. The price of rice increases. The prevalence of diarrhoeal diseases and measles also peaks during this season as a result of contaminated water. The quality of life is at its lowest since wages are down, staple food prices are up and landless labourers have meagre resources to draw upon. The vulnerable population are increasingly at the risk of health and life (Haider 1991a).

About 30 per cent of the sale of cattle and goats over a nine month period occurred during March to May, the pre-monsoon dry period where little agricultural activities are undertaken and another 30 per cent during September to November, the post-monsoon dry period, another period of low wages. Over 70 per cent of sellers of land, livestock and other resources cited food/family needs as the principal reason for the distress sales (Jabbar 1990).

Peak season employment from December to January provides work for more than 40 hours per week for 95 per cent of men; while most work 60 to 70 hours per week and some 10 per cent of men work more than 80 hours per week. In the peak season, 97 per cent of women also work more than 40 hours per week, mostly processing paddy. However, during the slack agricultural season, most men and all women are found to work less than 40 hours per week, a high level of underemployment and unemployment (Manpower Survey 1980).

Annually, a landless person can expect to have approximately, 200-220 days of agricultural employment, 20-30 days of non-agricultural labour and

115-145 days of unemployment (Haider 1991a). The fluctuating employment opportunities and income earnings clearly present a precarious existence for the landless family with access to limited resources.

Household Expenditure

The landless family struggles to subsist on a varying and meagre income. The land produces not only rice, the staple food for cultivators, but also the cash income needed for other household outlays. In the absence of land, the landless are forced to purchase rice and other food items, an expenditure that can monopolize 80 to 85 per cent of the household's income (Jansen 1987). Like-Minded Group (1990) cites the rural poor spending some 70 per cent of their earnings on food grain alone. World Bank (1990) found that the average Bangladeshi family's expenditure on food and clothing was 67 per cent, rent and fuel 17 per cent, other consumption 10 per cent, 3 per cent on transport and communication and another 3 per cent on medical care and education. A disproportionate share of the household income is spent on food. Expenses being greater than income, families are caught in a process where they gradually have to deplete their already meagre assets and land (for those who still own some) in distress sales in order to purchase food grain.

Food Consumption and Nutritional Status

The decline in the per capita food intake in rural areas, from the FAO recommended 2273 calories per day per person, is shown in Table 2.

Table 2

Per Capita Food Intake in Rural Areas (grammes/day)

Food items	1962-64	1975-76	1981-82	% changes between 1962-64—1981-82	1975-76—1981-82
Cereal	545.8	523.0	487.9	–10.6	— –67
Animal	56.5	44.0	44.0	–22.1	0
Vegetables, Pulses Others	283.7	240.3	232.6	–15.3	— –3.2
K. cal	2301	2094	1943	–207	–517

Source: Nutrition Survey of Rural Bangladesh 1981-1982.

Not only is the consumption of cereal, basically rice, the staple food and primary source of carbohydrate and calorie needs declining, but also, a drastic reduction in the consumption of fish, meat and pulses, the principal sources of protein intake has occurred over time in Bangladesh.

Entitlements

Unemployment or low-paid wages *vis-a-vis* the proportion of household income allocated towards food purchases means that the poor are hard put to keep themselves at the subsistence level. The impact of pauperization is such, that the large numbers of destitute families seeking work, drive wages down while the high demand for food pushes prices up (Jansen 1990). Pauperization is also a process whereby people gradually possess less and less entitlements to food (Sen 1981). People get entitlements to food through growing their own, working for money so that they can buy food, trading or by being directly lent or given food. Many more go hungry, regularly, because they lack entitlements, in the shape of land, jobs or anything to trade in the first place (Jackson 1990). Farmers lose their entitlements to food because their crops fail and they have no food reserves. Due to crop failure, they have no purchasing power to buy food despite its availability. Casual, migrant and service labourers are also affected since their earnings drop in relation to the price of food. Little demand for their labour and service means a cut-back in their earnings causing them to fall on hard times (Like-Minded Group 1990). And so poverty spreads.

Vulnerability of Women

The environment of poverty has had the following impact on the social fabric of society: extended families are breaking into nuclear families, compelling men to migrate in search of livelihood. Left behind are a large population of poor, female-headed households who are already amongst the poorest; under-resourced and now subject to serious labour constraints as they face the prospect of having to seek off-*bari* (outside-the-home) employment. Some 25 per cent of landless families are female-headed and the trend is increasing. More and more women are entering the labour market as primary, secondary or sole rice earners, either in their village homes or as migrants. In two-thirds of male-headed landless and marginal farm households, women

earn one-third to one-half of the total family income. One out of four landless households are headed by women who are responsible for the financial support and food security of herself and her children (Mahmud 1990).

Famine abandonment, observed in all the recorded famines in Bengal and in the climate of poverty today, explains that in times of crisis, a man can cut off his support to his dependents: first, his clients, then his distant and close kin and finally his wife and children (Maloney 1991). Famine abandonment can occur to the extent, that in times of extreme stress as in Cyclone 1991, a father caught in the tidal water, helplessly released his daughter; "*this son has to carry on the family line.*" (BCAS 1991).

Triple Burden

The effect on the woman now abandoned or at least minus the support of the traditional rice earner is multiple. She now has to precariously balance three roles:

- Management of the household and
- child-rearing responsibilities and
- wage employment.

She is responsible for the farm work as well as other subsistence activities as a result of absent male labour input. Non-farm work, also carried out by women, is essential to subsistence, in terms of provision of edible food, water and fuel. This three fold role takes its toll. In an environment of pressure and poverty, the woman is the 'poorest of the poor'; under-fed, in poor health, illiterate, over-worked, deprived and a victim of the triple burden (Haider 1991a).

Resources and Gender

Paradoxically, inspite of frequent references to women as natural resources' managers and *de facto* environmental managers; in their roles as producers and providers of food and agricultural products and income earners; women with limited access to resources are yet required to manage; and despite being earners, women's incomes are disproportionately lower than that of men. Women are at the bottom of the pay and power scales in agriculture: they are employees not employers; unpaid sowers, reapers and breadmakers, not breadearners on the family farm (Seager and Olson 1986).

Table 3

Gender and Class Inequality Within the Resources Nexus

Resource	Gender Inequality			
	Within Class		Between Classes	
	Men	Women	Affluent Women	Poor Women
AGRICULTURAL				
Capital/credit	loans for productive activity	available in small amounts, income to supplement family income	more options, less risk, productive use	less options, more risk, subsistence activity
Poultry/ livestock	commercial efforts	home-based income earning activity	raise cows, goats	sharecrop poultry
Labour power	command others, sell one's own	may sell, control only women	hire others for household work, harvest processing	sole resource of many women
Land	control	rarely owned	reflected status of family ownership basis for women's position	landless

Table 3 (Continued)

Resource	Gender Inequality			
	Within Class		Between Classes	
	Men	Women	Affluent Women	Poor Women
NON-AGRICULTURAL				
Employment	most options	marginal limited	choice, within limits	necessity, limited options
Capital resource available		limited availability	more	less
Family	mobilized for male support	security	support possible	limited support
Household/ village networks	internal and external, to village	limited	programmes provided, possibilities for external networks	restricted support systems
Skill/ education	increase competitive capabilities, skills to improve production	home oriented traditional skills, not increasing women's competitive capacity	skills monopolized in order to increase resource base	blocked in obtaining new options

Table 3 (Continued)

Resource	Gender Inequality			
	Within Class		Between Classes	
	Men	Women	Affluent Women	Poor Women
SOCIAL INFRASTRUCTURE				
Judicial/courts *salish*	open arena, dominate	closed, never members	—	—
Medical care	more frequent, allopathy	rare homeopathy	more likely	rarely
Agricultural extension	male oriented, field crops	generally excluded or included in terms of homestead	more likely to know of, rarely use on own initiative	irrelevant

Source: Like-Minded Group 1990.

Table 3 shows the limited access of women, particularly, poor women to resources.

Erosion of the country's natural resource base has intensified the level of poverty. Furthermore, inequal access to the same depleted base has created the feminization of poverty. Women have a smaller share of the pie. Since the pie is already small, their share is smaller still. Endemic poverty leaves the women further marginalized, whereby she is less able to draw sustenance from an economy where incomes fall and prices rise. This gender deprivation includes economic as well as non-economic inequities; access to potable water, sanitation facilities, basic health care, education, housing and very importantly, the environment of physical security.

Women's Labour: A Realistic Appraisal

Some of the prevailing myths relating to women's economic participation include the following:

MYTH 1 : Men need employment for their families, women need only income generating activities to perform in their spare time as an extension of domestic activities.

MYTH 2 : For women, independent income-earning and working outside the home is socially unacceptable.

MYTH 3 : Disadvantaged groups, particularly women, cannot be granted credit since they have no collateral against loans and their capacity for repayment is low.
(Cited in Haider 1991)

Contradicting such beliefs, (Safilios-Rothschild and Mahmud 1989) found in a survey of 4,000 rural households, that 55 per cent of women are engaged in productive work, in addition to household chores and domestic work. Furthermore, disputing the belief that women are negligibly involved in agriculture, survey results revealed that some 40 per cent of these women were directly engaged in various kinds of primary agricultural production; 17 per cent in field agricultural work on their own farms, 12 per cent as agricultural wage labourers and some 10 per cent in homestead production of vegetables, livestock and poultry.

Agricultural work by women is also far more prevalent among the landless and marginal households, since these women are forced under econo-

mic duress, to seek outside-the-home wage employment. Women in smaller land-holding households are often found to be working long hours as unpaid family labourers in agricultural activities. Women from medium to large land-holding households are less engaged in agricultural work and are more likely to engage women from the landless and marginal households to undertake the agricultural tasks.

Considerable overlap in agricultural production, both in decision making and tasks, between men and women, particularly, in marginal and small farm households was also found by (Safilios-Rothschild and Mahmud 1989). In male-headed households, non-traditional agricultural tasks such as spreading fertiliser and pesticide and operating irrigation equipment, are undertaken by both men and women in some 20 per cent of households and by men alone in the remaining. The less non-traditional tasks such as transplanting rice, harvesting, stripping jute fibre and weeding are jointly performed by men and women in 45-60 per cent of households. Conventionally female tasks of crop processing, livestock care, storing and preserving seeds and crops and homestead crop cultivation are performed by women alone in the large majority of households (over 80 per cent). In female-headed households, most agricultural tasks, both traditional and non-traditional are all carried out by women alone.

In a study, (Islam 1991) on women's involvement in income generation, expenditure-saving and household maintenance, the value of each activity was quantified, based on labour input, market value and the service value transfigured into monetary unit, adopting local wage rate and market value for the produced resources. Sources of income focused on women's contributions to homestead agriculture including kitchen gardening, planting of horticultural and forest species, poultry and livestock raising, pisciculture, food, fuel, fibre, wood and cash as major components of the household economy. Unrecognized, undervalued yet basic to growth and survival are the expenditure-saving activities related to family welfare, such as child-rearing, cleaning, cooking and household maintenance.

Women's share of earnings from household activities was found to be 68 per cent of the total household activity earnings. Despite a 60 per cent level of participation by women in income generating activities, their share in earnings was only 32 per cent of total earnings. Regarding the household's expenditure-saving activities, women constituted 73 per cent and men 27 per cent of the participatory level. The market value of expenditure-saving

activities contributed by women stood at 61 per cent, while in household maintenance activities, women's service value was found to be 94 per cent of the total involvement of men and women (Islam 1991). The evidence places a monetary value on the commonly undervalued contribution of women to the household economy. The market value found a high level of contribution by women in a wide range of economic activities but not corresponding financial recognition.

In the area of homestead agriculture production, the role of women is critical. More than 50 per cent of women from landless families dominated decision making on vegetable production. In the actual production of vegetables, about 70 per cent of women as compared to 14 per cent of men were involved (Islam 1991). This source of food can not only provide the family with necessary nutrients, in an otherwise precarious state of nutritional intake, but also provide extra income if a surplus is grown.

Working Scenario

The profile of women entering the wage labour market is characterized by one of need. Income from a woman's productive labour has become imperative to the family's survival. While 7 per cent of male and 15 per cent of female urban workers left families whose landholding is of 1-11 decimal size, 5 per cent of the males and 2 per cent of the females originate from families who own 12-21 decimals of land (Hossain *et al.* 1990).

The woman in a marginal situation is compelled to rely on agricultural wage labour in households with surplus crop. If she becomes a migrant, then reliance on domestic service and labour intensive industries such as the garment industry, bakeries, pharmaceuticals, tea, jute milling, electronics and fish processing is probable. Textile weaving and the apparel industries are the largest employers of women in the industrial sector, accounting for 46 per cent of the female work-force (LFS 1984-1985). The jobs these women hold carry low pay, low status and little job security, in other words, *job ghettos* (Seager and Olson 1986). The training women receive in these *job ghettos* has been described as training to be underpaid and obsolete (McGrath 1976).

The occupational hazards are numerous. Being employed is not necessarily an indication of a better situation, since here too, she is likely to be exploited, deprived and exposed to unsafe conditions. Female employees, in

the garment industries which earn substantial foreign exchange for Bangladesh, encounter chemically treated fabrics and dust from cloths while working in uncongenially small areas. Harassment by male colleagues is also a regular feature.

The sericulture industry is also dominated by women. They grow silkworms, take care of the cocoons and feed the bred insects. Continuous exposure is hazardous to health, a condition ignored by employers and owners. Women brick-breakers with their infants, inhaling dust particles have become a common sight (Rahman N. 1991).

Table 4 projects a rapid increase in female labour participation from 11 million in the 1980s to 25 million in 2000.

Table 4

Female Labour Force Projection in Rural and Urban Areas 1980-2000

(In million)

Year	Rural	Urban	Total	Projected Participation
1980	2198	312	3230	11.0
1985	4000	506	4506	13.5
1990	5585	849	6434	16.6
1995	7644	1329	8973	20.4
2000	10141	2061	12202	25.0

Source: World Bank 1983.

Investment in Women: The Returns

Considerable evidence exists to show that investment in women brings about improvement in their position and in the situation of the children and family. The most appropriate intervention for poverty alleviation in Bangladesh would be to increase investment in the girl child and woman.

- Under the Grameen Bank loan scheme, 22 per cent of the female loanees, were found to contribute 50 per cent or more to household income.

- Among women with trade skills engaged in income-generating activities, more of them preferred smaller numbers of children, larger gaps between children and more than 90 per cent supported family planning.
- Women with work experience outside the home have considerably lower fertility across all age groups than those without such experience. Female characteristics, especially work experience, may be more important determinants of fertility than the husband's characteristics.
- Given limited resources, personal well-being and conspicuous consumption are more male characteristics while expenditure priorities are more development oriented among women. Nearly all male Centre Chiefs of Grameen Bank owned wrist watches though none of the female Centre Chiefs owned a watch.
- A study in southern India found that 80 to 100 per cent of women's wage income was devoted to family maintenance, whereas men committed between 40 and 90 per cent.

(Cited in Haider 1991)

Nutrition and Health

Decreasing purchasing power of the family has manifested itself in overall decline in nutritional intake. Traditions of food distribution within the family, demand that women eat last and least in both quantity and quality. Table 5 shows the decline in calorie consumption among women *vis-a-vis* men. Particularly alarming is the decline among the nutritionally vulnerable group; pregnant and lactating mothers.

Girls under 5 years partake 16 per cent less calories than boys of the same age group. Among children 5-14 years, girls consume 11 per cent less calories than boys 5-14 years (Haider 1991a). Girls, therefore, enter marriage and motherhood from a pre-existing fragile state of health.

Anaemia is prevalent among 50 per cent of all women and the prevalence is even higher among pregnant women. Almost all low-income pregnant women in Bangladesh weigh less than 50 kgs; a state of body conducive to miscarriages, still-births, low-birth weight babies and high maternal mortality levels, about 6 per 1000 live births. The environment of poverty and the ensuing triple burden means that it is a physical impossibility to expend more calories in work than one takes in as food, except at the expense of

body tissue. Pregnancy and particularly lactation, likewise place enormous physical strains on a woman's body (Rogers 1989).

Table 5

Per Capita Calorie Intake

	Male			Female		
Age	75-76 (K.cals)	81-82 (K.cals)	% Change	75-76 (K.cals)	81-82 (K.cals)	% Change
20-39	2962	3154	+6.48	2437	2254	-7.51
40-49	2866	2955	+3.11	2272	2115	-6.91
50-59	2702	2791	+3.29	2193	2114	-3.60
60-69	2569	2840	+10.55	2088	2134	+2.20
70 +	2617	2776	+6.08	1463	1830	+25.09
			Pregnant	2340	2068	-11.62
			Lactating	2447	2305	- 5.80
			P+L	1921	2083	+8.43

Source: Nutrition Survey 1981-1982.

The health problems of women other than those related to reproduction and nutrition, include diarrhoeal diseases, gastro-intestinal problems, skin diseases, respiratory infections and eye, ear and dental diseases. Diarrhoeal and gastro-intestinal ailments are closely linked to environmental conditions, namely, availability of potable water and sanitation facilities.

Gender bias extends to reporting of illnesses. Women report illnesses which affect the head of household more often than their own. Men report illnesses of women when the household is affected in economic terms, depriving the household of their significant contribution (World Bank 1990). Differences in utilization of health services by females is reported by (Chen *et al.* 1981). Women are hospitalized at a more advanced stage of an ailment, thus giving them a lower probability of recovery and a longer period of confinement.

Foraging for Fuel

In the past, access to common property renewable resources had provided the rural population with sustenance from life-support systems in the form of open water-bodies for fishing and fish consumption, a vital source of animal protein and common lands for cattle grazing, cultivation, fodder and forestry. A wide range of vital resources had been freely available to people. According to (Singh 1985) in India, commonly available wood, shrubs and cow dung had been utilized for cooking and heating; mud, bamboo and palm leaves for housing, wild grass and shrubs for animal fodder and a variety of fruits and vegetables as food. Such an environment was the survival base for rural India and the domain of productivity of women (Shiva 1988). The situation was not dissimilar in Bangladesh.

Forests are a natural resource rapidly being depleted by over-use, at times for survival. Commercial felling for timber and other uses, together with encroachments for agriculture and settlements have substantially reduced the forest area and increased water and soil instability. Total Reserve Forest Area has been reduced by 50 per cent during the last 20 years. Fuelwood stocks have been reduced to the point, where over 84 per cent of the total domestic energy requirements have to be met by crop residues and animal dung, with only 16 per cent being met by fuelwood (Rahman A.A. 1991). The utilization of animal dung as fuel deprives the soil of vital nutrients and compounds the cycle of need, consumption and ecological instability. Deforestation and forest degradation, through water and soil erosion, turns both the land and the forests into unproductive and desertified wastelands (Shiva 1988).

In order to convert food into an edible form, some form of fuel is required. The task of fuel collection falls to women and for them, it is a strategy in survival. Supply of crop residues and animal dung is scarce for marginalized women, both rural and urban. They have to rely on fuel mass; leaves, twigs and branches, travelling further and further away in search of it, an exercise demanding more and more time and further damaging to their health.

Water Carriers

Rapid population growth, increased consumption of water and climatic factors have placed pressure on existing water sources. There is some indication

of a lowering of the water table, due to indiscriminate use of ground water in Bangladesh. Shortages of water in the river systems during the dry season are thought to be causing the saline belt to move northwards (Rahman A.A. 1991). Although some 80 per cent of the population are within 150 metres of a tubewell, its use is largely limited to drinking purposes. However, this coverage is also being increasingly threatened by the lowering of the underground water level during the 2-3 months of the dry season (Haider 1991a).

As some sources of water dry up, other waters are polluted by faeces, industries and agro-chemicals (Rahman 1991). As a result, water-borne diseases account for the majority of illnesses and deaths in Bangladesh. Typhoid, paratyphoid, shigellosis, streptococeal infections, diptheria, hepatitis and amoebiosis are some of the most common forms of diseases whose micro-organisms are found in polluted water. Many communities depend on such water sources for meeting their daily requirements, including drinking water. The situation further deteriorates during the post-flood and monsoon periods (Rahman N. 1991). Consumption of diseased fish is also frequently reported in the print media as a cause of deaths.

Increased salinity in the river waters of the southern region of Bangladesh, attributed to the construction of the Farakka Barrage in India, has been found to affect the health of expectant mothers in the region. Accumulation of water in the womb, resulting in respiratory ailments and debilitating effects were reported by some 50 per cent of pregnant women in the area. Known as the 'Farakka Syndrome' in extreme cases, it is suspected that the mother's kidneys may be permanently impaired and the foetus may be severely damaged (Ahsan 1991).

Human porterage is the most common means of transporting water in rural areas and for the vast majority of urban slum dwellers. It is an activity which is time-consuming, arduous, can be injurious to health and is almost exclusively, the domain of mothers and daughters. Distance to source, terrain to be crossed, queuing time, number of consumers in the household and number of females available in the household to transport the water are aspects women have to face. Given the energy-sapping anaemia widely prevalent in Bangladesh, water-carrying, further impairs womens' fragile health. Slipped discs, paralysis and broken backs are injuries common to water carriers. Fifty per cent of all broken neck cases in a rehabilitation clinic in Bangladesh were the result of falls while carrying heavy loads (Curtis 1986).

Impact of Disasters

The battle for survival emerges as the more difficult of the twin impact of a devastating event. Disasters kill people in vast numbers. The trial of trying to live against all odds is the monumental challenge for survivors. The vulnerability of women is accentuated under conditions of disasters.

During Flood 1988, some 6,50,000 flood-affected people took shelter in 353 relief camps in Dhaka city (Morshed 1991). Thirty per cent of the environmental refugees were men, 34 per cent were women and the remaining 36 per cent were children. Women who took shelter in camps were not secure. Anti-social elements created fear and panic among women. Movement of women was difficult since they could not move about in the open. The prevalent purdah system also made the evacuated women uneasy about living in the same area among unknown men. Destitute female refugees, particularly, younger women, faced considerable physical and social insecurity (BCAS 1991 and Adnan 1991).

In the area of sanitation, women face particular difficulties due to their need for privacy. Men, are found attending to nature's call in the open. Women have no such liberty; disaster or no disaster. Gunny-sacks were found useful as curtains to provide an element of privacy for women attending to nature's call during Cyclone 1991. In the Sirajganj district following Flood 1988, 400-500 women assembled every morning, on the only high and dry plot of land in the village, queuing for use of the only available walled-toilet (Morshed 1991).

"*Women will never come out into the open like beggars to receive relief*", said a female survivor of Cyclone 1991. Whatever the form of relief: cooked or uncooked food, clothing; most people with access were men. Few women queued for relief, victims of social restrictions. "*We were not allowed to go to the relief centres by the men in our families*." The few women and children who did join the queue came from very poor families. They were almost ashamed to be hungry and queuing for food. Women and children were always at the end of the queue. Women eat last and least during normal times and they queue last; if at all, in times of disasters. The relief in the early days after the cyclone was essentially accessible to the able and strong. Families with more male members had greater access to scanty relief supplies. Families headed by women had little chance or came last in getting relief. A woman in Kutubdia said on the 9th day after the cyclone. "*I*

have lost everyone and everything. I have lost my last dignity by queuing up for relief, I don't even get that, I wish another 'big one' would come and wash us all away" (BCAS 1991).

Differential Mortality

Disasters accentuate mortality differentials among men, women and children. Following Cyclone 1991, a report from Kutubdia, an off-shore island in the Bay of Bengal, observed that 85 per cent of all dead bodies belonged to women and children. Other sources also confirmed the finding. Investigations revealed the following :

Decision-making

Women depended on men to decide when or whether they should leave home for a safer place. Women and children stayed at home until it was too late. One businessman on his way home to remove his family to safety, decided not to risk it when he realized the water level was rising. He climbed a tree and lived. His wife and children who were waiting for him at home died.

Protective Instinct

How had they lost the grip that was the lifeline for the child? More men lived to relate incidents about their children being swept away from them. Few women survived to tell the tale, once they had to let go of their child. Nazrul Islam and his wife had seven children. The wife took charge of the four younger children and the husband took charge of the other three. All of them took shelter on the roof top. After one hour, the seven year old daughter was swept away from the husband's hand. All others survived.

Sari

In some cases, the sari itself became a death trap. Some women found themselves naked the morning after the cyclone and were hiding in water up to their neck until someone found them clothes collected from nearby dead bodies. Most women who survived, either discarded their saris themselves or the strong current took it off their bodies. Taking clothes off dead women to cover themselves had a traumatic effect, as some felt guilty for being alive (BCAS 1991).

Conclusion

If poverty is defined as the material experience which is a result of dispossession, deprivation and a denial of basic needs, (Shiva 1988), then the past review and analysis of the situation of women in Bangladesh corroborates the view that poverty has a gender bias; in that, it is the women of Bangladesh who are, disproportionately, victims of the environment of poverty.

Poverty is both a cause and a consequence of environmental degradation. Poor people have few options. For self-sustaining reasons, they tend to have large families. With growing numbers and no way out of their situation of poverty, they are driven to use resources faster than that which can be replenished. Population pressure and its greater absorption of the natural resources of land, forests, water and its dependent life support system, flora and fauna, animals and fisheries, mean that survival itself becomes an issue. And for the poor, there is little scope for adaptation.

Excessive human interference resulting in the erosion of the human resource base has had more of a negative impact on women than men. The downward and upward spirals of poverty and environmental degradation further reinforce the inequitable access of women to means of livelihood—land, employment opportunities, education and credit facilities, while conditions of economic duress force women into the wage labour market. Increases in the price of basic commodities, particularly, food and fuel have resulted in a decrease in real income. Reduced household spending has had serious implications for the nutrition and health condition of the woman. Her physical state is undermined by her eating last and least and the negligible attention paid to her health. In the event of natural disasters, the vulnerability of women is only accentuated.

Ironically, widely lauded as principal resource managers, women have to manage with a minimum of resources; both in terms of economic and non-economic resources. The combined environment of pressure and poverty and the inherent gender bias results in women becoming the 'poorest of the poor', under-fed, in poor health, illiterate, over-worked, deprived and a victim of the triple burden.

> It is rare to find a case in which environmental destruction does not go hand in hand with social injustice, almost like two sides of the same coin.
>
> Anil Agarwal, Centre for Science and the Environment, Delhi, India.

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CHAPTER TWELVE

CHILDREN AND ENVIRONMENT IN BANGLADESH

Lopa Khan and Helen Rahman

Introduction

Only nine countries in the world have over fifty million children under sixteen years of age. Out of these, a startling fact is that only three countries have nearly fifty per cent of the population that are children. These are Nigeria (50 per cent), Pakistan (48 per cent) and Bangladesh (46 per cent). The area of Pakistan and Nigeria is over five and a half to six and a half times greater than Bangladesh and both countries have substantial natural resources. Therefore, in comparison the per capita resources is stretched to its limits in Bangladesh.

A child being born into such an impoverished environment has slim chances of reaching his or her full potential in adulthood. Their stunted physical and mental growth impede them from fully contributing to the society.

Environmental degradation affects children more than any one else. Fatal diseases for the major proportion of children are environmentally related. Unsafe water, polluted air, hazardous chemicals and above all, poverty resulting from environmental mismanagement and natural disasters are the main causes of death of children.

Over the years, there has been remarkable achievement in reducing mortality among children through immunization and the discovery of oral saline for diarrhoea in Bangladesh. However, these improvements are short-

lived if squalid living conditions are not improved. For example, children immunized against diphtheria will still die from other pulmonary diseases if air quality and living conditions are not improved.

Progress in education has been disappointing in our country. The government has generated many reports and recommendations but these have mostly been rhetoric. Literacy rate over the past twenty years has decreased for boys, and only increased by one per cent for girls.

Together with a rapidly deteriorating natural environment, children's situation is aggravated by the social environment. Poverty forces children to work up to fourteen hours, to support their family. They cannot go to school and many are pushed into prostitution and drug abuse.

Children need special protection. Their needs must be separately considered in the process of development because they are unable to speak up for their rights. Developing human resources must be given priority for breaking through the vicious circle of population and poverty.

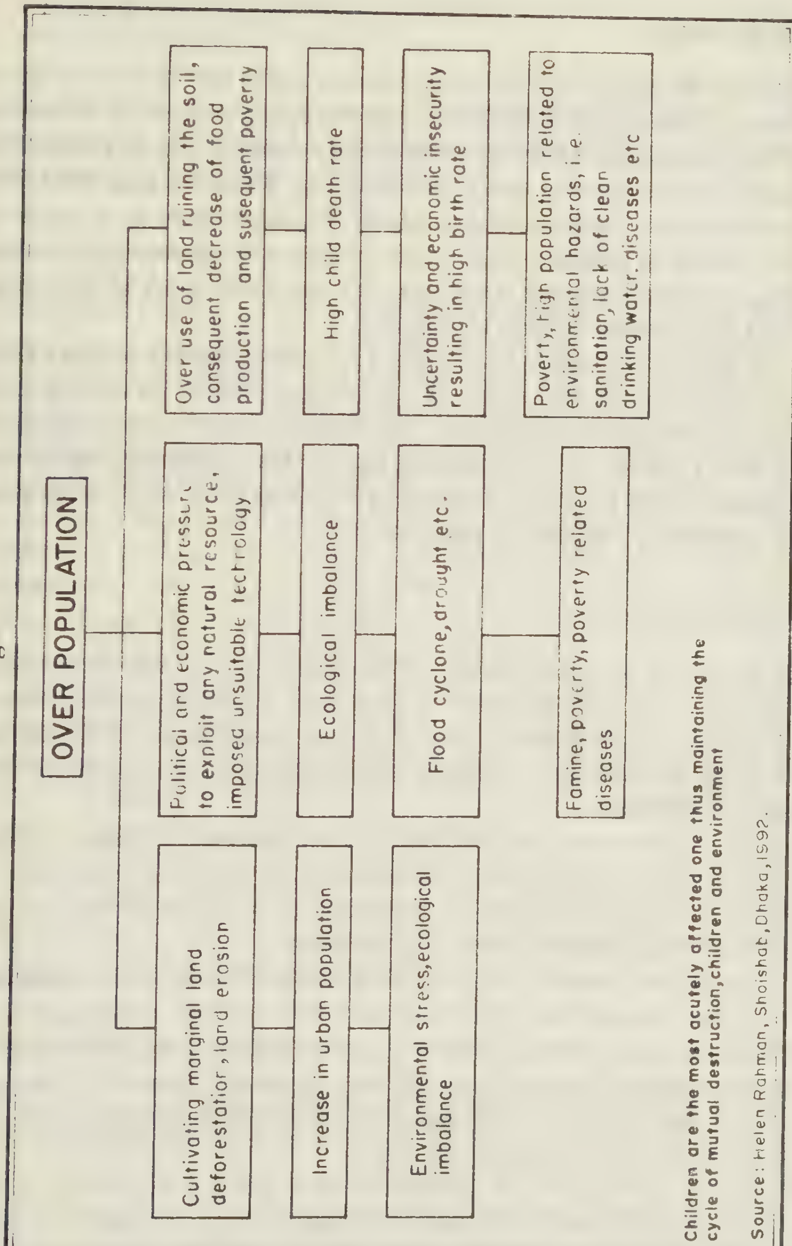
Effect of the Environment on Children

Poverty

The adverse effect of poverty is essentially due to a high population to resource ratio. Overextraction in terms of farming, fishing, deforestation etc. is leading to less and less being made available for all (Figure 1). Overextraction is often compounded with the evils of shortsighted development schemes. In Bangladesh, fish is a major source of protein. Fish is gradually decreasing since flood protection embankments have stopped fishes from spawning in the flood plains. Malnutrition of pregnant women and children has horrifying implications. It causes low birth weight, irreversible damage to the foetus, disease and high infant mortality. This in turn, makes people want to have more children, adding to unsustainable population growth.

Poverty in rural areas has caused urban migration to the four major cities in Bangladesh. Population of these cities and towns have tripled and quadrupled. Dhaka, the capital city is unable to cope with waste, sanitation and water supply for over 3.5 million people. Children live in utterly unacceptable conditions in slums. Many are rapidly turning to crime, drug abuse and prostitution.

Figure 1


OVER POPULATION
Cultivating marginal land deforestation, land erosion
Political and economic pressure to exploit any natural resource, imposed unsuitable technology
Over use of land ruining the soil, consequent decrease of food production and susequent poverty
Increase in urban population
Ecological imbalance
High child death rate
Environmental stress, ecological imbalance
Flood cyclone, drought etc.
Uncertainty and economic insecurity resulting in high birth rate
Famine, poverty, poverty related diseases
Poverty, high population related to environmental hazards, i.e. sanitation, lack of clean drinking water, diseases etc
Children are the most acutely affected one thus maintaining the cycle of mutual destruction, children and environment
Source: Helen Rahman, Shoishab, Dhaka, 1992.

Air pollution

Ambient air quality in rural areas in Bangladesh is considered to be good. However, overcrowding and absence of ventilation at home has an adverse effect on children. Many die of pulmonary diseases such as pneumonia, tuberculosis, diphtheria, and whooping cough. Women in rural areas cook on woodstoves, leaving the child nearby. Emissions from the woodstoves are harmful to pregnant women and children. Carbon monoxide reduces oxygen concentration of the foetus. This can cause death of the unborn child, brain damage and low birth weight.

In urban areas, vehicle emissions and particulate matters from brick fields cause air pollution. Reconditioned vehicles emit black smoke that can cause bronchial irritation, infection and other diseases. Lead is still allowed as an additive in petrol. Children inhaling lead can have haematological effects. Intelligence and behaviour is also affected by lead in the air. Street children are particularly vulnerable to lead inhalation.

Water pollution

Bangladesh is a riverine country. Most of its area is covered by wetlands. Contamination of surface water by pathogens is a major cause of diseases like cholera, typhoid, paratyphoid, diarrhoea, gasto-enteritis, and infectious hepatitis. Poor drainage, unplanned irrigation promote malaria, hookworms and schistosomasis.

There is not much data available on chemical contamination of surface water and ground water. Infants and children are vulnerable to chemicals in water because their tissues and organs are immature to act as a defense mechanism against pollutants (UNICEF 1990).

Bangladesh uses over a million tons of chemical fertilizer and around four and a half thousand tons of pesticides per year. Farmers may not use agro-chemicals in proper proportions. It is possible that localized pockets of high contamination of surface and ground water are present. General consensus is that fish have been affected by pesticides. It needs to be found out whether it is accumulating in the aquatic food chain.

Nitrate fertilizers may contaminate ground water can cause methaemoglobinaemia in babies. Their digestive system rapidly converts nitrate into toxic nitrite. Nitrite combines with haemoglobin in the blood,

preventing it from carrying oxygen. Nitrites can also be a source for causing cancer (Goldmith and Hildyard 1990).

There is not much information regarding ground water contamination by industrial chemicals or heavy metals. The Department of Environment made some tests for chromium in a major tannery locality in Dhaka. It was found that chromium was present in the ground water.

Natural disasters

On April 29 1991, a cyclone and tidal surge of enormous calamity hit the coastal areas of Bangladesh which left 138,000 dead. Only in Kutubdia, it was observed that 85 per cent of dead bodies belonged to women and children. They were most vulnerable because the women depended on men to decide whether they should leave home for a safe shelter. Women invariably stayed at home with young children until it was too late. From the oral narration of survivors, it was found that some parents favoured the life of their sons to daughters. A father stated that he held on to his son and daughter for dear life to keep them from being swept away by the tidal surge. When it became impossible to do so, he released his daughter. He said, "this son has to carry on the family line" (Haider *et al.* 1990).

Similarly, children are the first to suffer in times of drought. The northwest region of Bangladesh is threatened by desertification. Increasing aridity is thought to be due to diversion of water from the Ganges during the dry season in India. The northwest area has the highest proportion of children suffering from malnutrition (UNICEF/FREPD 1981).

Extensive deforestation and aridity necessitate women and children to spend more time collecting biomass and water. Household chores are more cumbersome and time-consuming, leaving less time to spend on education and any other productive work or leisure.

Hazardous environment

Children are more prone to accidents than adults. In Bangladesh, accidents cause a significant number of deaths in children. Accidental injuries are also a serious problem. In urban areas, scavenging street children have a high probability of tetanus through cuts and scratches. Lack of space forces many children to play in the street or on the roof. Other causes of death are,

bus accidents, ferry capsizing, drowning and ingestions of pesticides in rural areas etc.

Status of Children in Bangladesh

It is thought that Bangladesh has entered the third phase of the demographic transition (Figure 2). The previous high rate of fertility has declined somewhat from 47/1000 to 33/1000 live births. Crude death rate has substantially dropped since the late 1930s from 40/1000 to about 11/1000 live births. Some experts believe Bangladesh is still in the second stage (Hossain 1990) with no significant drop in the birth rate.

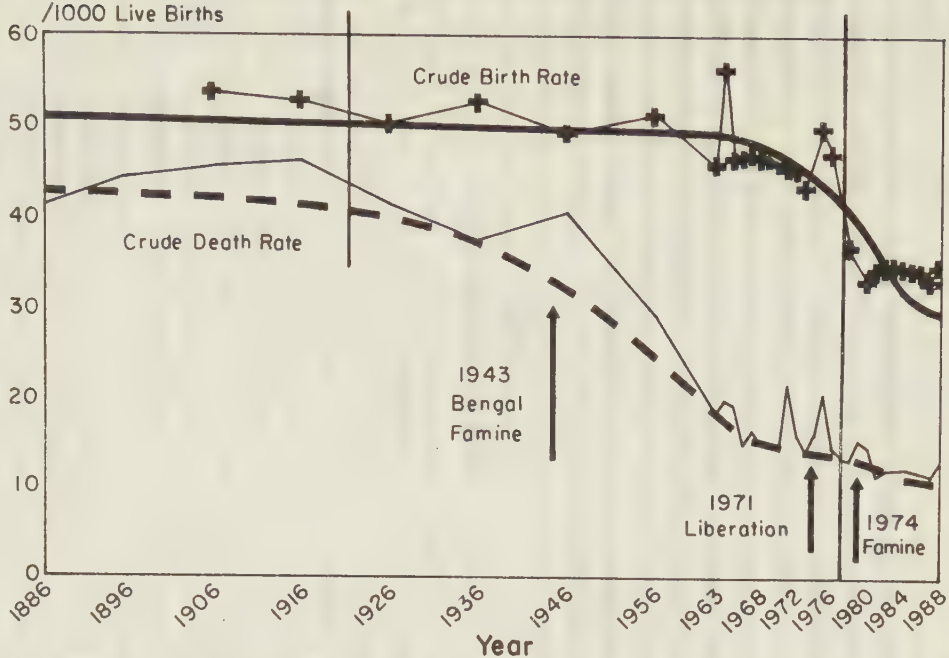
Infant mortality rate for under five years (U5MR) although reduced by 8 per cent in the past thirty years is still appalling. Out of 129 countries, Bangladesh is in the 23rd position with a high mortality of 180/1000. This compares miserably with the lowest U5MR countries such as Japan, Canada, Sweden and Hong Kong where U5MR is under 10/1000 live births. In the richer developing countries, such as Republic of Korea, Malayasia and Thailand the figure is around 25/1000.

Although 8 per cent lowering of U5MR seems like a small figure, it has caused a large bulge in the population curve. Children comprise 46 per cent of the total population. Such high figures will not be lowered until parents are confident of their children's survival into adulthood. Parents are then likely to consider having fewer children (UNICEF 1990).

Well-being of children depends on the ability to meet basic needs. In prenatal and early infancy, environmental needs are related to food intake, protection of mother's health and the home environment. In the pre-school period, health, nutrition and recreation are the basic needs. The child needs more space for play and mental growth. During the school period, the child begins to interact with the community. Children of the highest socio-economic strata, are mainly receivers and consumers of goods and services. They have less of a role in changing or affecting the physical environment. Children belonging to lower socio-economic strata are more active. They work alongside their parents in farming, household chores and sometimes in outside work so they have an active interaction with the environment. Therefore, for them, the quality of the natural environment is more vital. Pollution of air, water and soil affect them directly because of their intensive activities in the outside environment. In addition to health and nutrition,

Figure 2

THE DEMOGRAPHIC TRANSITION IN BANGLADESH



Bangladesh has already passed through three stages of the demographic transition. The fourth stage will be achieved when the birth rate declines further and equals the death rate. The overriding goal is to achieve a stable population.

Source:
UNICEF / GOVT. OF
BANGLADESH 1990

education also plays a major role in enhancing children's potential. Table 1 lists the needs of children at different ages. The nature of the needs will vary from place to place and from rural to urban areas.

Health

For infants and young children, nutrition, health and protection of mother's health are the main areas of concern. First the good news. In recent years, the discovery of oral rehydration salts in Bangladesh has had enormous impact in reducing child mortality due to diarrhoea. Similarly, success of immunization in Bangladesh in the past few years has been phenomenal. In 1985, immunization reached only 5 per cent of the population. Within five years in 1990, about 70 per cent of infants aged under one year had been immunized (UNICEF/GOB 1990). Small pox has been eradicated. In view of the sheer number of children involved in the immunization programme, this is, extremely positive, provided it can be sustained in the future.

Table 1

Priority Needs for Children

Age group	Priorities	Needs
Prenatal birth	1	Health protection
and early infancy	2	Protection of mother's health
Weaning	1	Nutrition
	2	Health
Pre-school	1	Nutrition
Period	2	Health
	3	Recreation
School Period	1	Education
	2	Health
	3	Nutrition
	4	Recreation
Adolescence	1	Education
	2	Vocational training
	3	Health, nutrition
	4	Recreation

Source: Sicault 1963 and Ahmad 1977)

The immunization programme has other components such as control of diarrhoea with rehydration and feeding; Vitamin A supplement to children under six years to reduce nutritional blindness and promotion of breastfeeding. Vitamin A Supplement reached 46 per cent of children in 1982-83, the figure has declined to 35 per cent in 1989-90 (UNDP 1992).

Maternal mortality has also been reduced by 7 per cent since the early 1970s. The median age at marriage has risen from 19 to 24 for men and 13 to 17 for women over the past fifty years (BBS 1991). However, at least one study contradicts this figure. Median age for marriage of women was found to be 14 years in survey areas (UNICEF/FRPED 1991).

Much progress has been achieved in providing clean water in rural areas by shallow and deep tubewells all over the country. Eighty two per cent of rural people use clean water at least for drinking, seventy per cent of users live within 500 ft. (150 metres) of a tubewell. The Department of Public Health with the assistance of UNICEF has installed 600,000 public tubewells as of 1985. Prior to 1971, there were 200,000 tubewells. Simplicity and improvement of design of tubewells has reduced clogging to only about two to three per cent (UNICEF 1987).

Now the bad news, the ground water table in Bangladesh cannot sustain this enormous extraction due to public consumption, and irrigation purposes during the dry winter/spring/summer seasons, since the recharging of aquifers is less than the extraction. In many parts of the country, especially in the arid northwest, tubewells now cannot reach the water table. In the Dhaka metropolis and the surrounding areas, the water table has fallen twenty feet in the past five years (The Daily Star, April 20 1992).

Solving the problem of clean water was cheap and technically simple by boring tubewells. But it has overexploited nature. So that, we are now going back to square one. Complementary and alternative sources of clean water need to be supplemented.

Lack of sanitation regarding defecation in a densely populated area, with a high incidence of malnutrition result in a perpetual cycle of infection and further nutritional deficit in children (UNICEF 1990). While clean drinking water has been adequately made available, only an estimated six per cent of the population have a sanitary latrine. Children under five defecate close to home. Only 33 per cent of the rural population use a fixed place for defecation. Such bad habits are responsible for over thirty per cent of childhood mortality. Human excreta pollution of surface water cause

epidemics of polio, jaundice, typhoid, intestinal worms and parasites. It is possible to reduce the occurrence of cholera by seventy per cent through use of safe water and constructing toilets (UNDP 1992).

Recent studies by the International Centre for Diarrhoeal Diseases Research (ICDDR,B) has indicated that clean water alone is a necessity but not the only condition for reducing diarrhoea. Presence of a household latrine and personal habits such as washing hands are also very important (Henry *et al.* 1990). Furthermore, improved weaning practices, washing vegetables before eating and breastfeeding are effective interventions as well (Aziz *et al.* 1990). Public awareness of these is essential as is the supply of clean water.

Malnutrition

Poverty and ignorance about nutrition are the main causes of malnutrition of children, pregnant and lactating women. Nutrient intake per capita per day in Bangladesh has decreased over the past fifty years. Protein consumption and Vitamin A intake is particularly alarming. Table 2 shows per capita calorie intake as 1927 kcal/day instead of 2400 kcal/day which is the required intake.

Table 2

Trend of Nutrient Intake Per Capita Per Day in Bangladesh

Nutrients	1937	1962-64	1975-76	1981-82	1983-85*	1986*
Calories	2743	2251	2094	1943	1859	1927
Proteins	78.4	57.5	58.8	48.4		
Vit A (IU)	1850	1590	730	763		

Source: Recommended daily intake: 2400 Kcal/day.

Is Nutritional Status Deteriorating in Bangladesh ?" Roy S.K. *et. al.* Health Policy and Planning 1988, 3(4): 325-8

* Achieving Self-Sufficiency in Food, Planning Commission, 1988.

* World Development Report, UNDP 1989.

Seventy per cent of pregnant women are deficient in iron and other micro nutrients. In the northwest, 80 per cent are deficient in iodine. Iodine deficiency in neonatals can cause mental retardation (WHO 1972). The small stature of women and the nutrient deficiency have adverse effect on babies. At least half of children born in Bangladesh weigh below 2.5 kg, which is considered high risk in developed countries.

The UNDP compilation of nutritional data from various surveys is shown in Table 3. In 1990, nearly 46 per cent of rural children under 5 years suffered from chronic malnutrition characterized by stunted growth. Twelve per cent suffered from acute malnutrition characterized by wasting conditions in which irreversible damage may occur. Malnutrition increases slightly during the monsoon and post-monsoon seasons due to scarcity of food. Malnutrition is highest in the northwest, the Rajshahi district. In urban areas, chronic malnutrition is slightly less at 41.4 per cent, acute malnutrition is significantly less at 6.2 per cent (BBS 91).

Table 3

Intertemporal Comparison of Nutritional Status of Children under Five Year Age Group in Rural Bangladesh from Six Surveys

	Agency/Year						
Indicator	INFS (1975-76)	INFS (1981-82)	BIDS (1982-83)	BIDS (1982-83)	BBS (1985-86)	BBS (1989-90)	BIDS (1990)
Stunting	73.7%	57.3%	58.7%	52.25%	55.9%	52.2%	45.73%
Wasting	21.6%	20.0%	16.6%	14.46%	8.2%	8.8%	12.06%
Mid-upper Aim Circumference (<12.5 cm)	–	–	–	–	14.9%	11.0%	–
Age Range (months)	0-59 m. 0-59 m.	0-59 m.	0-59 m	0-59 m.	6-71 m.	6-71 m.	
Reference standard	Harvard	Harvard	NCHS	NCHS	NCHS	NCHS	NCHhS
Sample Size	430	510	1003	1003	1500	2356	199

(Rural + Urban)

Source: Chowdhury (1991 as cited in UNDP 1992)

Report of the Child Nutritional Status Survey 1989-90, BBS, April, 1991, p. 24.

Table 4

Prevalence of Wasting (Acute Malnutrition) in Children by Age Group, Area and Sex (Weighted)

Age Group (Months)	Male			Female		Combined Sexes	
	Urban %	Rural %	Total %	Urban %	Rural %	Total %	National %
6-11	4.8	10.0	4.5	6.1	11.3	10.0	10.0
12-23	14.7	11.5	11.8	18.3	23.0	22.4	16.8
24-35	7.0	8.2	8.0	7.6	11.6	11.2	9.6
36-47	4.0	4.2	4.2	5.8	6.4	6.3	5.2
48-59	5.8	4.8	4.9	2.1	5.7	5.2	5.1
60-71	4.8	5.0	4.9	4.1	4.1	4.1	4.6
Total	6.7	6.8	6.8	7.1	9.8	9.5	8.1

Source: Bangladesh Bureau of Statistics, Report of the Child Nutrition Status Module: Bangladesh Household Expenditure Survey 1985-86. Dhaka, 1987, Table 18, p. 26.

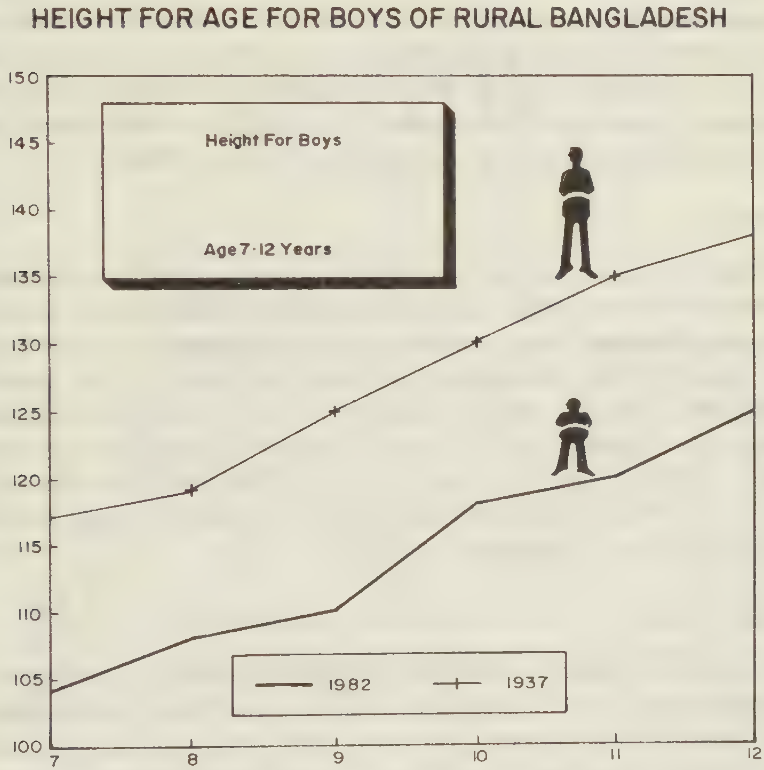
Table 4 shows the acute malnutrition of children by age, sex and area. Two vulnerable group of children can be identified.

- Highest incidence of acute malnutrition is seen in infants aged 12-23 months. This is the period when most wean off breastfeeding and start receiving inadequate supplementary food.
- Malnutrition of girl infants aged 12 to 47 months is significantly higher. Malnutrition drops off to about 4 per cent for older children, however, there is evidence that the height of boys aged 7-12 has dropped by 13 cm. in forty five years. (Figure 3).

Other studies show that malnutrition decreases with income and the mother's education. Nutrient deficiency is halved at incomes higher than 4000 takas per year and halved again over 8000 takas per year. Rate of malnutrition of children of mothers with some primary education (Class IV) is around 30 per cent, considerably less than the national figure of 46 per cent.

Figure 3

Situation of Children and Priorities for Action



Source: UNICEF 1990

Gender bias

Table 4 shows acute malnutrition of rural girl infants aged 12-35 months which is over double the rate for boy infants. A variety of socio-economic reasons, such as cultural preference of males over females, expectation of male children contributing financially later on, early marriage and leaving the family by girls etc. are the cause of gender bias. Female mortality under the age of 4 can exceed male mortality by up to 70 per cent as parents are less likely to provide them medical attention (Mahmood 1987).

Illnesses

Malnutrition increases the risks of infection by two fold than normally nourished children. Major causes of morbidity of children under five are diarrhoeal diseases, worm infestation, skin diseases and acute respiratory infections. Malaria primarily occurs in the southeastern part of the country and tuberculosis and leprosy in the northwest. Prevalence of nutritional anaemia is very high due to worm infestation and deficiency of vitamins A and C which are necessary for absorption of iron. Neonatal infants die mainly of tetanus and infants weaning die from diarrhoea. Figure 4 shows child mortality from various diseases.

Education

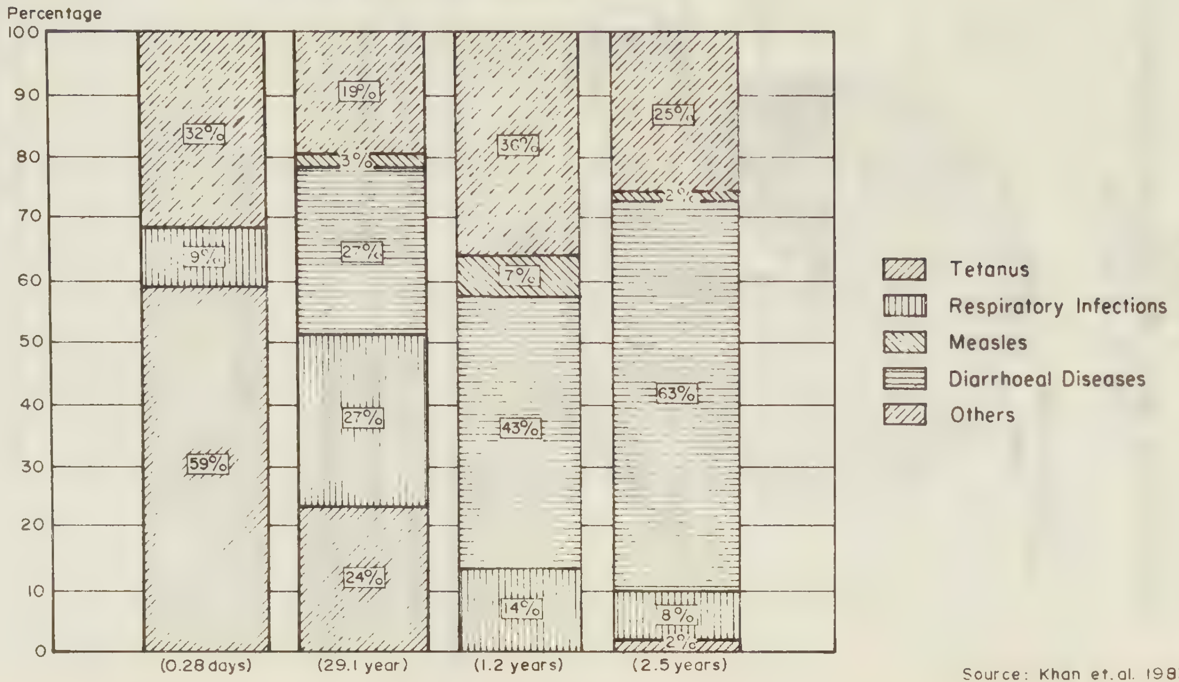
The education sector is lagging behind the health sector in achieving any significant rise in the literacy rate. Overall literacy rate has marginally declined to 23.8 per cent according to the 1981 census (Table 5). Literacy rate for males have also declined by nearly two per cent and for females it has increased by four per cent.

The number of government primary schools per ten thousand has remained stagnant at 4.1 schools, while the number of students per teacher has substantially increased from 50 to 61 students making learning difficult, as children receive less attention (Table 6).

Figure 5 shows the population of young school children by type of schools. It is seen that 61 per cent of children attending school are serviced by the 45,000 or so government primary schools. The number of private religious schools have increased from a few thousand to 22,000 in recent years. Religious schools enrol about 17 per cent of students.

Figure 4

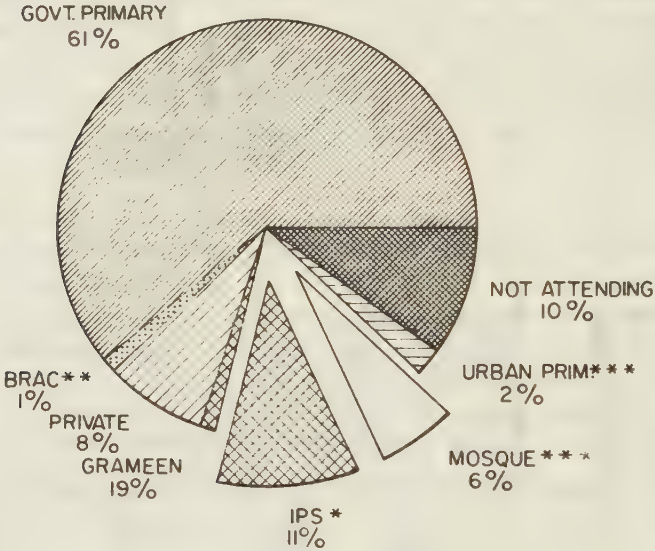
BANGLADESH
INFANT AND CHILD MORTALITY RATES 1983
BY AGE GROUP AND DISEASE



Source: Khan et. al. 1983

Figure 5

POPULATION OF YOUNG SCHOOL CHILDREN BY TYPE OF SCHOOL



* Islamic schools, voluntary attendance, community supported religious education

** School is supported by NGO but not major focus of NGO activity

*** Mosque school, religious education, community supported, pre-primary

**** Urban schooling patronised by elites

Source: UNICEF 1990

Table 5

Literacy Rate by Sex and Region

District	Male		Female		Total	
	1974	1981	1974	1981	1974	1981
Dinajpur	30.3	25.3	9.9	11.8	20.5	21.6
Rangpur	22.4	21.0	17.9	10.2	15.4	18.1
Bogra	28.5	25.6	12.4	14.6	20.6	22.9
Rajshahi	25.4	23.3	10.6	13.0	18.2	20.7
Pabna	20.3	20.9	8.9	12.7	14.8	19.2
Kushtia	20.7	18.8	9.9	11.3	15.5	17.1
Jessore	29.0	26.2	12.7	14.7	21.1	23.3
Khulna	36.0	34.2	17.7	21.3	27.2	31.3
Patuakhali	33.1	31.2	16.2	23.0	24.8	30.7
Barisal	33.8	33.3	19.9	27.4	27.0	33.7
Faridpur	25.1	23.6	10.4	13.9	18.0	21.3
Dhaka	32.8	33.3	16.4	22.2	25.2	31.3
Tangail	23.3	22.5	9.8	13.5	16.8	20.2
Mymensingh	20.0	19.0	9.3	12.0	14.8	17.6
Sylhet	25.3	22.1	10.4	13.1	18.1	19.9
Comilla	28.5	25.2	12.3	16.6	20.1	23.7
Noakhali	30.8	27.6	13.1	19.3	22.2	26.5
Chittagong	33.6	30.7	13.0	18.1	24.0	27.9
Chittagong H.T.	24.1	25.9	7.5	10.3	16.4	21.5
Bangladesh	27.6	25.8	12.2	16.0	20.2	23.8

Source: BBS Statistical Yearbook 1991.

Table 6

Primary Education Facilities

Year	No. of Schools per 0,000 population	Primary Students per Teacher
1975	4.0	50.7
1981	4.7	47.3
1982	4.6	49.2
1983	4.5	S50.1
1984	4.5	52.5
1985	4.4	54.6
1986	4.3	59.8
1987	4.2	62.1
1988	4.1	62.1
1989	4.1	61.1
1990	4.1	61.7

Source: BBS Statistical Yearbook 1991.

BRAC, one of the biggest Non-Government-Organization (NGO) has expanded repidly since 1985 from twenty-two schools to six and a half thousand schools in 1991. BRAC schools teach three years of primary education to the poorest children of landless families.

The government primary schools are unable to satisfy the demands of the community. Up to seventy per cent of children drop out before reaching the fifth grade (UNICEF 1990). Drop out rate is the highest in the first year, followed by the second year. Of the remaining, attendance is low and irregular and girls literacy rate, 16 per cent is half that of boys 31 per cent. The northwest region has the lowest literacy rate.

Poverty is said to be the main cause of parents' taking children out of school, even though primary education is free. Parents are unable to meet incidental expenses in clothing, stationary and special fees. Rural and urban

children spend a lot of time on farming, household chores and outside work. Other problems include lack of teachers and irregular attendance, lack of equipment and school rooms, long distance to schools, unimaginative and irrelevant curricula and stress on examination and rote learning of facts and figures.

Only thirty percent of children go on to formal higher education. Vocational training centres for children are only a few in number. UCEP, a NGO has one vocational school in Dhaka teaching from six to grade eight. (Karim 1992).

BRAC Primary Schools: A Sparkling Drop in a Bucket

"BRAC schools give me real cause for hope and confidence that basic education for all can be achieved."

Peter Goldmark, President, The Rockefeller Foundation.

BRAC challenged the popular belief that poverty caused children to drop out of school. They established 22 rural schools in 1985. At present, they have 6,500 schools and are planning to expand up to 12,000 schools by December 1992 and the long-term plan is to establish 100,000 schools by 1997. So, far the drop out rate at their schools is around 2 per cent. 98 per cent of children go on to complete three years of schooling. In teaching the three 'R's reading, writing and arithmetic BRAC is giving priority to female children and recruiting female teachers.

The secret of their success? It is in their teaching method, the commitment of teachers, a low teacher-student ratio of 1:30 and in teaching relevant and practical knowledge such as how to protect poultry from disease, how to protect oneself from contagious diseases, how to measure and do basic accounting etc. Their enormous success in a very difficult situation has almost proved, that poverty is not the only cause for not attending school.

However, a massive bottleneck can be foreseen in the primary education sector if the enormously successful non-formal education of BRAC schools are not accommodated by the government primary schools. If BRAC achieves its target of establishing 100,000 schools by 1997, then, around 3,000,000 (100,000 x 30) students will have completed grade three. Many

of these students will like to go on and transfer to the 4th grade in the government schools. Therefore, we need more schools, and teachers, i.e. more spending in the education sector.*

The curriculum of the government schools also need to be accommodative. Otherwise, massive numbers of children will lose interest and drop out again at grade four. Of particular concern is the English and Religious studies offered in grade 4 of the government schools. The Education Commission headed by Dr. Kudrat-e-Khuda, a renowned educationalist recommended reducing the load of English and Arabic in the primary stages, as it might be too difficult for young children to cope with three languages (Sharfuddin 1992).

Rural working children

Children are faced with demands for their labour within the household and the pressures of poverty push them into the labour market (Ahmad and Quasem 1991). These forces compete to keep children out of school.

In the rural area, working children are common among small farmers and illiterate parents. A village's proximity to an urban centre as opposed to remote villages had a negative effect on children working. Economic opportunities meant more income for the family and less work for the children. Rural children work in a variety of jobs mostly complementary to women's work (Table 7). Girls spend 71 per cent of their time on housework and 25 per cent on agriculture. Boys spend the reverse.

Urban Working Children

The population of the four major cities of the country, Dhaka, Khulna, Chittagong and Rajshahi has trebled and quadrupled over time. Migration is due to environmental factors such as loss of land due to riverbank erosion, natural calamities and economic factors.

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*Since writing of this paper, the government has substantially increased spending for education. In the 1992-93 budget development expenditure in education has been increased to 11 per cent from 5.6 per cent. Of this, 8 per cent will be spent on primary and mass education. Revenue budget meeting recurring expenditure of the education sector has been increased to 18.6 per cent from 14.7 per cent in 1991. (The Daily Ittefaq, June 19, 1992).

Table 7

Type of Work Done by Female Child Workers in Villages

Activities
Raising animals.
Working in vegetable gardens
Collection of cowdung
Boiling and drying of paddy,

Types of Work Done by Male Child Workers by Villages

Agriculture	Non-agriculture
Catching fish	Weaving fish nets
Cottage industries	Earthen house repair
Raising animals	Trading in pottery
Harvesting crops & vegetables	Assisting in rice Trading
Pulverising the fields	Rickshaw pulling
Collection of fuels and grass	Worker in tea stalls
Marketing produces	Helper in masonry work
Raising seedlings	Assisting in rice trading
	Helper in bus driving

Source: Ahmad and Quasem 1991.

In Dhaka, acute shortage of land and housing has resulted in slum settlements. Density of population in these slums can be as high as 400,000 people per square mile or 625 persons per acre. In other parts of Dhaka, density ranges from 50,000 to 100,000 people per square mile. (Mahbub and Islam 1990). The magnitude of the problems related to garbage disposal, sewage, sanitaticn, water supply and other amenities is not difficult to imagine, especially, the plight of children.

A study of two rural areas in Bangladesh confirms that overcrowding of 10 or more people in a home increases the mortality of infants under 12 months by up to three times (Rahman *et al*. 1985). It is possible that this is true for the urban situation as well. Most diseases in slums are environmentally related. Children suffer from diarrhoea, asthma, typhoid, measles, diphtheria, pneumonia and worms. Many people in slums even believe that worms are good for digestion. To make matters worse, up to

thirty per cent of adults, mainly women suffer from mental breakdown and disorders. Rape, divorce, suicide and murder are frequent. Single women maintaining a family is common. Health facilities are nonexistent. Most slums are not visited by any social workers (Ahmed Nur-E-Alam 1987).

Both boys and girls are engaged in outside work. Girls have a heavier work load at home and look after siblings while both their parents work outside. Only 30 per cent of the boys and 25 per cent of the girls enrol in school. In other areas of Dhaka, school enrolment is 80 per cent. Table 8 gives the various occupation of street children and their daily income. On average, children work 10 hours a day and some work up to 14 hours a day. Children preferred least to be domestic servants and were least likely to go to school if servants.

They servant also get waste food from different hotel, fool plus 1 to 3 taka daily. Restaurants by cleaning plaster and glass or rubbish. Sometimes they can earn Tk.15-20 daily by extorting money from younger children.

Increasingly, street children are becoming involved with drugs and prostitution. Girls are often abused while sleeping in the streets. The police estimate that juvenile crime rate is nationally about 5 per cent and 15 per cent in Dhaka.

Case Studies*

Shaheen, 14 Years, Occupation: Carrying Loads, Cleaning Buses

Shaheen came to Dhaka with his mother, when his father died. After sometime, he left his mother because he was beaten by her. He became acquainted with an older man and started working for him as a servant. He worked for two years and went to school up to class 2. He could not get along with his wife. He left and stayed in various slums. He met his mother about six months ago and stayed with her briefly before moving on again. Now, he does not like to work very much, instead he bullys young children into giving him money as he was forced to do when he was young. He loves to go to the movies. He is involved in drugs and sex abuse.

*Source , Shoishab Bangladesh, Dhaka.

Table 8

Occupation & Average Daily Income of Urban Children

Occupation Average daily income	Average daily income
Cleaning cars/Motor Cycles	Tk. 10-20
Rag Picking/Scavenging	Tk. 15-20
Porter	Tk. 30-40
Pimp	Tk. 20-30
Prostitute	Tk. 40-50
Shoe shining	Tk. 40-50
Vegetable collection from the market & reselling	Tk. 20-30
Vending (Chocolate, Newspaper/ water/bags/Flower garland)	Tk. 20-30
Rickshaw van poller	Tk. 50-60
Pushing carts/Carriages	Tk. 40-50
Begging	Tk. 20-25
Stealing/Rick pocketing	No fixed income.
Gambling	No fixed income.
Servant	Food plus Tk. 1-3
Cleaning plates/glasses/rubbish from restaurants	Left over food
Extorting younger children	Tk. 15-20

Source: Shoishab Bangladesh.

Nasima, 14 years, Occupation: Child Prostitute

Nasima came to Dhaka about five or six years ago. Her father died. Her mother had a small grocery shop in the village. One of her neighbours, a lady told her to run away to Dhaka. Nasima stole 100 Tk. from the shop and came to Dhaka with the lady. The lady abandoned her when they reached Dhaka. Nasima could not go home because she does not know the address.

At first she started begging, then scavenging and working as a domestic servant. She did not like the confinement of working at home. So she went

back to the street life. Nasima is an intelligent and attractive girl. She finally succumbed to prostitution. New she feels frustrated and degraded being a prostitute. She has resorted to taking sleeping pills.

Conclusion

Development expenditure in Bangladesh has been skewed in favour of the power and natural resources sector (22 per cent), flood control and water resources (19 per cent), agriculture (16 per cent) and transport sector (14 per cent). Spending on health and education has been around 1 per cent and 5 per cent respectively (BBS 1991). Development is focused on acquiring tangible goods like roads, bridges, embankments and electricity. Intangible goods such as health, education and quality of life has been given lower priority.

It is necessary to combine both, for a more holistic approach to development. Children are the basic unit for whom development is most relevant. After all, if the well being of the future generations is not assured, then why any development at all ? Development is meant to eradicate hunger, illiteracy, disease and inequity for successive generations of children. At the moment we are spending very little to achieve this. No doubt this is because children are the silent majority, they cannot voice or approach the government into meeting even the rudimentary of their needs and requirements.

Q.K. Ahmad (1977) suggests we compile a national database on the children's profile in Bangladesh first and then identify the target groups before planning an action programme and expenditure. Our survey of available literature indicate:

- Children of ages one to three as the most vulnerable, especially female children.
- Regionally, the condition of children in general are worst in the northwest areas of Rajshahi, Bogra, Rangpur and Dinajpur.
- The condition of children in the slums of Dhaka are much worse than others. A starting point of action can be health and education projects for these identified groups, based on further research.

In the education sector, BRAC, the religious schools and the education department need to consult one another as to how to effect maximum benefit by working in unison. It would be a national shame if eager children from

BRAC schools are not absorbed by the government schools because of a rigid, and unyielding system. Time and again, the need for curricula changes in the government sector have been recommended. Now it is absolutely essential that it be changed.

The situation of working children cannot be improved without economic development and changes in the attitudes of parents and employers in their willingness to exploit children. Direct means of legislation of children's rights has been largely unsuccessful due to non-enforcement.

Indirect means of alleviating some of the miseries can be achieved by commitment to primary education and encouraging vocational training. The number of vocational and polytechnics are only 18 in the country (Sharfuddin 1992). A few NGO schools such as UCEP are inadequate to meet the demand. Small businesses within the community may be encouraged to train older children in trades, such as tailoring, carpentry, plumbing, lock and key making, shoe repair etc.

Finally, the media and the welfare organizations have a large role to play in putting pressure on the government to achieve its stated targets in the 4th Five Year Plan. They can continuously evaluate and assess the success of development programmes concerning children.

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CHAPTER THIRTEEN

URBANIZATION AND THE URBAN ENVIRONMENT IN BANGLADESH

Nazrul Islam

Introduction

Bangladesh, with a current population of over 110 million people, is the eighth most populous country in the world, but only about 20 per cent of its population live in areas officially defined as urban. It is also one of the least urbanized countries of the world. The urbanization level is low even by standards of most other developing countries. On the other hand, if the total urban population is considered, Bangladesh stands remarkably high. In fact, the total urban population of Bangladesh (which is currently over 22 million), is higher than the national population of some 92 countries of the world, including those of Australia, Canada or Saudi Arabia). Since the total area of Bangladesh is small, only 144,000 sq. kms., the overall density of population is very high (763 persons per sq. km. in 1991), and the average gross density of population of urban areas is also extremely high. Thus in Dhaka, the largest metropolitan area in Bangladesh, the density is 20,000 persons per sq. km. while in medium and small towns, the density may range between 3,000 and 15,000 persons per sq. km.

The already existing high absolute population (in both rural and urban areas), high densities and the high growth rate have major implications on the quality of the physical as well as social environment of the country as a whole and the urban areas in particular. In urban areas, such implications are manifested in the acute land and housing situation, particularly, in the

proliferation of slums and squatters, in the transport crisis, in the difficulties in providing adequate and safe drinking water, in problems of managing the sewerage, sanitation and drainage systems and in garbage disposal services. The implications are also evident in the poor quality of health, education and community services. Rapid urbanization also causes deterioration in the visual or aesthetic environment of the city, as well as in the social, moral and cultural environment. The present paper attempts only to highlight the impact of urbanization on some of the above aspects. This discussion is, however, preceded by an analysis of the trends and patterns of urbanization in the country.

Urbanization Trends

Bangladesh has traditionally been an agrarian and rural society. Although the heritage of rich urban centres goes back to the 3rd century B.C., urbanism in the ancient period was extremely limited in scope and extent. There were only a few small towns even until the end of the medieval period. During the Mughals (16th-18th centuries), the region, or Subah Bangla at the time, entered into an important stage of urbanization, when craft and cottage industries flourished and several major urban centres were developed around industrial concentrations. Dhaka, with a large urban population, dominated the urban pattern of the region throughout the Mughal period. In the British period (1757-1947), cities and urban centres gained greater momentum and many new centres were established. But large scale urbanization did not take place due to the absence of industrialization. The British towns emerged mainly for collection of exportable surplus and for creating an administrative base. These towns were mainly parasitic in nature, in the sense that, they were not productive or manufacturing centres. They received more than they offered to their rural hinterlands.

In the truest sense, the transforming of rural areas into urban centres prior to the 20th century was not visible. Even the first two decades of the present century did not show any remarkable change (Table 1). Thus, only 2.43 per cent of the total population lived in urban areas in the Bangladesh region in 1901. For the next two decades, until 1921, the proportion of population living in urban centres remained almost static. Since 1921, there has been a slow but steady growth, except for the early 1940s, when there was a temporary set back due to World War II.

The political changes that took place in the Sub-continent in 1947, had far reaching implications on the economic and social situation, including the trend of urbanization. The impact was visibly very significant on the region which is now Bangladesh. First, large scale migration took place across the new international boundary. Millions of Muslims moved from India to East Pakistan and settled almost wholly in the existing urban areas. Secondly, new centres of trade, commerce, industries and administration were set up in the new province. There had also been significantly large scale rural to urban migration in the newly independent country. The natural growth of urban population was also high. As a result, a significant rate of growth of urban population was recorded in the Bangladesh region between 1951 and 1961, being 45.11 per cent as against only 18.38 per cent in the previous decade. The rate of annual (exponential) growth of the urban population during 1951-1961 was 3.72 per cent.

Table 1

Growth of Urban Population in Bangladesh 1901-1981

Census Year	Total Urban Population (Million)	per cent of Population Urban	Decannial Increase of Urban Population (%)	Annual Growth Rate (Exponential) (%)	
				National	Urban
1901	0.70	2.43	–	–	–
1911	0.80	2.54	14.96	0.87	1.39
1921	0.87	2.61	8.85	0.53	0.84
1931	1.07	3.01	22.20	0.68	2.00
1941	1.54	3.66	43.20	1.66	3.59
1951	1.83	4.34	18.38	0.50	1.58
1961	2.63	5.19	45.11	1.92	3.72
1974	6.00	8.87	137.57	2.62	6.70
1981	13.56	15.54	115.76	2.32	10.97

Source: (BBS 1987)

Phenomenal growth took place during 1961-1974, when the increase in urban population was as high as 137.6 per cent with an annual growth rate (exponential) of 6.7 per cent, nearly twice as much as that in the previous intercensal period. The share of urban population (in the total population) rose to 8.9 per cent in 1974 from 5.2 per cent in 1961, while the total urban population increased to 6 million in 1974 from only 2.64 million in 1961. This exceptionally high urban population growth rate can be explained in two counts. First, migrants from rural areas came in great numbers into the cities for employment and were absorbed mostly in the urban informal sector. As much as 38 per cent of the total population in 1974 have been estimated to have come from rural areas (Khan 1982). Secondly, the abrupt and dramatic change which followed the violent War of Liberation in 1971 and its resultant political change-over seem to have had some impact on the process of urbanization. Apparent and real increase in economic and social opportunities in the urban areas, worsening law and order situation and poor economic conditions in the rural areas and major environmental hazards like river bank erosion, floods and cyclones were largely responsible for the urban-ward migration of rural people (Islam 1986 and Mahbub and Islam 1989).

The growth of urbanization in the subsequent period was extraordinarily high. Thus during the 1974-1981 period, the overall growth rate was to the extent of 115.8 per cent in 7 years and the annual growth rate (exponential) was as high as 11 per cent. The proportion of urban population stood at 15.5 per cent in 1981, while the total urban population rose to 13.56 million, which was more than double the size of the 1974 urban population. Obviously, as in previous years, natural growth of urban population and migration from rural areas contributed to this exceptionally high rate of growth. However, a third factor also contributed significantly to this growth; the factor being the redefinition of urban areas. The 1981 census provided an extended definition of urban areas by including all upazila headquarters, irrespective of population size and urban characteristics, as urban places (BBS 1987). In addition, all rural *hats* and *bazars* with electricity were also classified as urban centres. This caused an inflation in the number of urban centres (which totalled 491 in 1981 as against only 119 in 1974) and in the total population in urban areas. The contribution of the redefinition factor to the growth of the urban population during 1974-1981 was to the extent of about 30 per cent, while natural growth

and migration contributed roughly 30 per cent and 40 per cent of the growth respectively.

Growth of Urban Centres and their Size Distribution

According to the 1981 census, Bangladesh has 491 urban centres. At the beginning of this century (1901), there were only 48 such centres in the present Bangladesh region (See Table 2).

By 1951, the number had increased to 63, but during the next 30 years, the number increased to 491 which is about 20 times higher than the number of urban centres in 1901. Among the 491 urban places, the four largest cities, namely Dhaka, Chittagong, Khulna and Rajshahi, have been given official status of metropolitan centres with municipal corporations in the municipal administrative system. These four largest cities accommodate 43 per cent of the urban population of the country, indicating urban concentration in few cities. Besides these four, there are 71 municipal towns of varying sizes (Figure 1) which absorb 25 per cent of the total urban population. Rest of the country's towns (416 in number) designated as other centres, contain 32 per cent of the urban population of 1981.

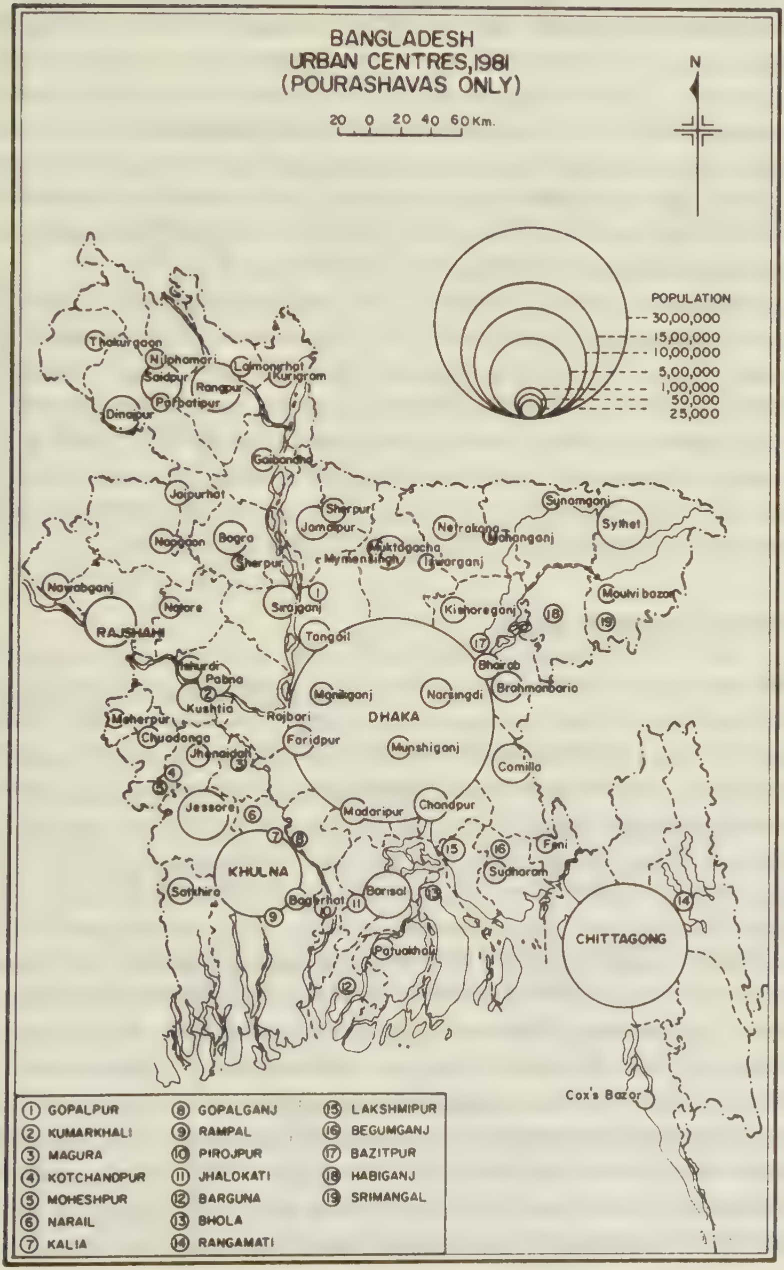
Table 2

Number of Urban Centres by Size 1901-1981

Size of Urban Centres	1901	1911	1921	1931	1941	1951	1961	1974	1981
All sizes	48	48	50	58	59	63	78	108	491
Above 1 million	–	–	–	–	–	–	–	1	2
100,000 – 999,999	2	2	2	2	2	2	4	5	11
50,000 – 99,999	–	–	–	–	2	2	5	14	23
25,000 – 49,999	–	–	5	7	13	14	15	23	46
10,000 – 24,999	21	23	20	21	20	20	23	49	117
5,000 – 9,999	15	13	13	17	19	18	21	12	129
Less than 5,000	10	10	10	11	3	7	10	4	163

Source: BBS 1987

Figure 1


BANGLADESH
URBAN CENTRES, 1981
(POURASHAVAS ONLY)
20 0 20 40 60 Km.
N
POPULATION
30,00,000
15,00,000
10,00,000
5,00,000
1,00,000
50,000
25,000
Thakurgaon
Nilphamari
Saidpur
Rangpur
Lalmonirhat
Kurigram
Parbatipur
Dinajpur
Gaibandha
Joipurhat
Sherpur
Jamalpur
Naogaon
Bogra
Sherpur
Mymensingh
Muktagacha
Netrakona
Mohanganj
Iswarganj
Sunamganj
Sylhet
Moulvi bazar
Nawabganj
Natore
RAJSHAHI
Sirajganj
Tangail
Kishoreganj
Bhairab
Brahmanbaria
Manikganj
Narsingdi
DHAKA
Munshiganj
Ishurdi
Pabna
Kushtia
Rajbari
Meherpur
Chuadanga
Jhenaidah
Faridpur
Comilla
Jessore
Madaripur
Chandpur
Feni
Sudharam
KHULNA
Satkhira
Bagerhat
Barisal
Patuakhali
CHITTAGONG
Cox's Bazar
1 GOPALPUR
2 KUMARKHALI
3 MAGURA
4 KOTCHANDPUR
5 MOHESHPUR
6 NARAIL
7 KALIA
8 GOPALGANJ
9 RAMPAL
10 PIROJPUR
11 JHALOKATI
12 BARGUNA
13 BHOLA
14 RANGAMATI
15 LAKSHMIPUR
16 BEGUMGANJ
17 BAZITPUR
18 HABIGANJ
19 SRIMANGAL

Classified according to population size, only 2 of the 491 centres in Bangladesh had attained the 'million city' category in 1981, (Dhaka and Chittagong). Until 1974 there was no 'million city.' Dhaka emerged as the only such city in 1974 (population 1.7 million in 1974) and Chittagong joined the rank in 1981 (population 1.4 million). These two cities absorbed nearly 36 per cent of the total urban population in 1981. There were 11 urban places in 1981 with population ranging between one hundred thousand and one million. These can be classified as cities. There were only 2 such cities between 1901 and 1951, 4 in 1961 and 5 in 1974.

During the first two decades of the present century, there were no intermediate towns (25,000-100,000) in the city-size classification of the country. Since 1921, intermediate size towns increased rapidly in number, from 5 in 1921 to 69 in 1981, thus filling a gap in the city size structure.

The number of small towns (with population below 25,000) grew phenomenally from 43 in 1921 to 409 in 1981, or 83 per cent of all urban centres in 1981. However, these small towns together absorbed only about one fourth (24.2 per cent) of the total urban population in 1981.

Future Urbanization

The rapid rate of urbanization in Bangladesh is likely to continue for quite sometime in the future, although a declining trend is foreseeable. In this context, the projection made by the World Bank in 1985, is worth considering. According to this projection (Table 3) the annual rate of urban population growth during 1974-1981 was taken to be 10.3 per cent and the share of urban population as 15.1 per cent of the total population. The growth was estimated to be 5.4 per cent for around 1990 and the urban share then at 20.1 per cent. These estimates appear tenable. The rates and shares estimated for periods beyond 1990 are quite uncertain, as these will depend on several rather unpredictable factors including political and natural environmental ones. If the trends projected stand correct, the total urban population in Bangladesh in the year 2000 will be 37.3 million and the share of urban population will be 26.4 per cent, these in the year 2015 will be 67.9 million and 36.8 per cent respectively (Table 3). If we extend these statistics to the year 2025, Bangladesh will have a massive urban population of nearly 90-100 million and an urban share of 45-50 per cent of the total population, when the total national population will be

no less than 200 million. The situation at such time is quite difficult to visualize.

Table 3

Urban Population Projection in Bangladesh, 1981-2015

Year	Total Population (million)	Urban Population (million)	per cent of Population Urban	Urban Growth % per annum
1981	90.0	13.5	15.1	10.3
1985	100.0	17.5	17.4	6.5
1990	113.7	22.4	20.1	5.4
1995	126.8	29.4	23.2	5.0
2000	141.1	37.3	26.4	4.8
2005	155.8	46.4	29.8	4.4
2010	170.5	56.8	33.3	4.0
2015	184.6	67.9	36.8	3.6

Source: World Bank 1985.

Urban Growth Process: Peripheral Expansion and Inner-city Densification

Urban growth and development usually take place both by:

- Expansion into non-urban rural areas and
- Densification of older or central areas of the existing urban centres.

The expansion into rural or non-urban areas can again take several forms, such as:

- Expansion into the contiguous fringes and all around the present urban built-up areas, giving a peripheral expansion pattern.
- Extension along the major transportation routes given a linear or finger-like expansion pattern and
- Expansion into outlying scattered locations causing leap-frog satellite form of development. For most of the smaller urban centres of Bangladesh, the first model is more common, while for the larger metropolitan centres, all the three forms of development are seen to be active. Thus in the case of Dhaka, peripheral expansion is taking place,

at least in three directions, highway-oriented expansion is also experienced, especially in the north and north-west direction, while satellite developments are also taking place.

Unfortunately, due to inadequacy of planning control, urban expansion in the fringes and outlying areas takes place in a haphazard manner and with potential for serious implications both on the physical environment and on the social structure of fringe area communities.

The other major type of urban development has been identified to be densification in central or inner areas. This has mostly been the case in metropolitan cities and other major towns. The densification process has been taking place in at least 3 forms:

- Through kind of a fission method.
- Through privately organized rebuilding or renewal activity and
- Through the growth of slum and squatter settlements.

In the first form or method, large old single family buildings or mansions, sometimes even 3 or 4 storied are subdivided into several one or two room tenement flats. This generally happens with the disintegration of large joint families into smaller nuclear ones. The flats can be either owner-occupied or tenant-occupied.

In the second form, rich business families rebuild their old, sometimes more than 100 years old houses, according to contemporary requirements. Often, residential units have been pulled down to build multi-storied commercial and residential units. This process is active in old Dhaka.

The third process, i.e., of slum and squatter formation, is of course, the most significant form of inner-city densification. The process is also active in the newer and fringe areas of large cities, thus increasing the overall urban population density. Slums and squatters have developed as a natural response to the needs of hundreds and thousands of the poor in urban areas.

Coverage of Land by Urban Usage

The rapid growth of urban population and of the number of urban centres have several implications, including the physical or spatial expansion of urban built-up areas. Although most of the urban centres in Bangladesh are small and show very high population densities, the total area covered by the 491 urban centres is not at all insignificant. No official or accurate data

about urban land coverage is available. However, on the basis of limited sample statistics, it can be estimated that approximately 1500 sq. miles (3885 sq. kms.) of land is at present under urban usage. This provides and average density of about 15,000 persons per sq. mile (or roughly 39,000 per sq. km.) for about 22 million urban population today. Thus approximately, 3 per cent of the total area of Bangladesh is at present under urban coverage. The share of land covered by both urban and rural settlements today, is close to 15 per cent (GOB 1980). The present urban population will more than double in the next 15 years (or by 2005 A.D.) and the consequent areal expansion will take away large share of the present agricultural land for urban usage. By the year 2025, when the urban population will be anywhere between 80 and 100 million, possibly over 12 per cent of the total land of Bangladesh will be urbanized while another 20 to 25 per cent will be covered by rural settlements or villages. Fortunately, urban expansion will be at a higher density compared to rural settlement but the overall depletion of agricultural land will be inevitable. How the lesser quantity of agricultural land can be expected to provide food for more than twice the present national population in about 30-35 years of time is difficult to imagine. Urban expansion will also have large scale impact on the environmental situation by partly disturbing the existing drainage system of the country unless urbanization takes place within a framework of rigourous physical planning.

Urban Poverty

In any analysis of the trends of urbanization and of urban growth, it is essential that the socio-economic status of the urban population is taken into consideration. In this context, the reality of urban mass poverty is of critical importance. It is difficult to make a proper understanding of the magnitude of urban poverty (or of poverty in general) for Bangladesh, due to conflicting statistics available from governmental or other sources. However, the Bangladesh Bureau of Statistics of the Government, claims that the poverty situation has improved in the recent years. Thus according to the Bureau, the urban population below the so called Poverty Level I (measured by affordability of a minimum intake of 2,122 calories per day per person) was 81.4 per cent in 1973-1974, 66.0 per cent in 1981-1982 and 56.0 per cent in 1985-1986 (BBS 1986).

Economists of the independent research organization BIDS, seem to support this BBS claim of improving poverty situation, but with reservation, noting that the improvement is not as remarkable as claimed by BBS data (Rahman *et al.* 1988). Other sources claim that the hard-core poor at present, constitute nearly 30 per cent of the urban population while the poor in general form over 50 per cent of such population (CUS 1989a). The proportions are likely to be higher for metropolitan cities. With these estimated proportions, the absolute size or magnitude of urban poverty in Bangladesh is disturbingly large. According to BBS, 7 million people belonged to Poverty Level I and 2.4 million to Poverty Level II in 1984-1985. Even with the decreasing trend of poverty, the size of population in 1990 in these two categories would be 11 million and 7 million respectively and by 2000 A.D. there would be 17 million urban poor and 9 million hard-core urban poor in Bangladesh (CUS 1989a).

The staggering magnitude of the urban poor has implications on the urban environment, because of their limited income and affordability or purchasing power. The implications are both negative and positive. Negative implications include their settling for substandard housing and low environmental quality, while one of the positive implications may be their willingness to economize on resources. For example, more than 50 per cent of the urban poor use only their legs to commute to place of work and thus reduce the demand for transport, ultimately saving the nation costs of fuel and vehicle import, as well as from traffic congestion and air pollution.

Some Aspects of the Urban Environment

The rapid pace of urbanization and the rather haphazard or uncontrolled pattern of urban growth and expansion in Bangladesh are manifest in the various sectors of the urban environment, such as in housing, transportation, water and sanitation, garbage disposal, drainage and flooding, health and nutrition, education, community services, air and the visual or aesthetic environment.

Due to difficulties in obtaining reliable and meaningful data and also as a result of the limited scope of the paper, it is not possible to discuss all the above sectors. Instead, some selected sectors like land and housing, transport, sewerage and sanitation and water facilities are highlighted.

Land and Housing

The consequence of rapid urban growth in a country where economic growth is either stagnant or at best, very slow, is nowhere more acutely evident than in the housing sector. Access to housing and to land for housing in urban areas is characterized by high degree of inequality. The majority of the urban population have access to only a small fraction of the urban land. For example, in case of Dhaka, for which there is some information, 70 per cent of the population of the city who belong to low-income groups and the poor, have access to only 20 per cent of the total residential land of the city, while the middle and upper income groups who constitute only about 30 per cent of the city's population enjoy control over 80 per cent of the land (Table 4 and Islam 1986). The ownership or control of land determines the access to housing services for the people. In general, land is in extreme short supply as a whole in Bangladesh, more so for urban usage and even more acutely, for large cities like Dhaka. Consequently, the price of land has increased by over 25 times in the last 15 years (Seraj and Alam 1989).

The scarcity of available land and its high price, as well as the existing large scale poverty and low affordability of the majority population, plus the poor and expensive transport system, have caused the development of extremely high density settlements in central parts of the city. The densities in the old city parts of Dhaka, on an average are more than 100,000 persons per square mile (258,990 persons per sq. km.). In slum and squatter settlements, this density can be over 150,000 persons per square mile (388,485 persons per sq. km.) or over 2,500 persons per acre (6178 person per hectare). This kind of density is unbelievable, considering the fact that the settlements are usually only one-storied. In the slums and for squatters, (or for the low-income population in general), the per capita residential or living space available is sometimes as low as 10 square feet (or 1 square metre), whereas the recommended minimum even for a low-income high density society cannot be conceived to be less than 50 square feet (or about 5. sq. metre). The structural conditions of the shelters are also very poor. These settlements are served with highly inadequate open space, streets, water, sanitation and sewerage facilities. Other urban amenities, like gas and electricity are also inadequate or even absent. Social services are equally poor.

Table 4

Dhaka Urban Area Housing Sub-systems by Income-Groups, Land Tenure and Land Coverage

Income groups/ Housing Sub-system	Type of Tenure	Approximate Proportion of City Population (%)	Approximate Coverage of City's Residential Land (%)
Upper Income Group	Freehold leasehold	2	15
Middle Income Group	Freehold	28	65
Low Income Group	—	70	20
Squatters (including pavement dwellers and vagrants)	Illegal mostly *Jhupri* type	(2.5)	(0.5)
Refugee rehabilitation colonies/ squatter resettlements camps (Govt. Assisted Housing)	Public land leasehold	(6)	(2)
Bustees			
Private rental type	Tenant	(35)	—
Private owner occupied	Freehold/ public land/ disputed	(5)	(11)
Conventional tenement slums (rental and owner occupied)	Freehold	(12)	(4)
Employees housing	Public land/ freehold	(7)	(2)
Other Low Income Housing	Various/ mainly freehold	(2.5)	(0.5)

(Islam 1985-1986)

A very large percentage of the urban population in Bangladesh live in slums and as squatters. Thus in Dhaka city alone, there are nearly 2 million people (or 30 per cent of the total population) who live in more than 1500 slums and squatter settlements of the city (Figure 2). The situation is nearly similar in the other metropolitan cities (CUS 1989a).

The housing condition in urban Bangladesh, in general, is quite unimpressive. If building materials are any indicator, only 15.72 per cent of the houses in the urban areas of Bangladesh were made of permanent or *pucca* materials (concrete floor and roof and brick walls) in 1981, 8.16 per cent were of semi-*pucca* type, 11.92 per cent were *kuccha* type and 64.18 per cent were simply thatched houses of very temporary materials. (Table 5). Even in the four metropolitan areas, nearly 64 per cent of the houses were of the *kuccha* type.

Table 5

Housing Types in Bangladesh by Urban and Rural Areas, 1981 (in per cent)

Household Types	National	Urban	Rural
All *pucca* (concrete for both wall and roof)	2.81	15.72	0.76
Semi-*pucca* (walls brick roof and C.I. Sheet)	2.18	8.18	1.24
Kuccha (with semi permanent materials like C.I. sheet and wood).	10.98	11.92	10.42
Thatched (very temporary materials)	84.03	64.18	87.58
Total	100.00	100.00	100.00

Source: BBS 1989.

The temporariness of building materials, signify a constant recurring cost of maintenance, repair and replacement. Inspite of the low standard and quality of housing, the cost of construction is not very low, neither, therefore, is the rent. Not surprisingly, exploitation is rampant in the rental

Figure 2

Fig-2

housing market, with the poor and the lower-middle-income group paying very high rents for per unit area of space. Thus in the slums of Dhaka, a poor family may be paying rent as much as 4-5 Tk. per square foot (43-54 Tk. per sq. metre) of space in a *kuccha* or thatched house without proper toilet facilities or other utility services (GOB, Ministry of Land 1989).

In all metropolitan cities, there is acute shortage of housing supply and the backlog is continually on the increase. For Dhaka city alone, the need for new housing or replacement will be at the tune of 40-50 thousand units a year in the coming years (Islam 1989).

The role of the public sector in the housing delivery has been insignificant. Housing has been supplied by the private household sector in a very unregulated manner and will continue in the same manner for some time. The private commercial sector has now become active and visible, but a profit-making attitude in this sector will further aggravate the environmental and other problems in the city. The multi-storied apartment blocks or buildings are being put up without proper consideration for adequate open space or for traffic generation in the immediate neighbourhood. Social environmental issues are hardly considered.

Transport

While urbanization is significantly dependent on the growth and development of the transportation system, in turn it creates tremendous demand on the system. As the rate of urban expansion and urban population growth has been extremely rapid, transport facilities could not be expanded at the same rate or pace. This is particularly true for the large metropolitan centres. The problems of transport inadequacy in Dhaka has been particularly critical. The formal urban transportation system which consists mainly of buses and trucks, is far short of needs. The informal transportation system dominates. There is a complex mix of motorized and non-motorized transports. In most urban areas, cycle rickshaws dominate the streets with their numbers. Other informal transports include baby taxis, *'mishuks'*, auto-*tempoes*, and mini-buses. There are also cycle vans and push carts. Private cars are only significant in Dhaka and Chittagong. Official or institutional motor vehicles are of some importance also in the large cities.

Although, the growth of the transport sector has not been proportionate to the growth of population and demand for transport, the absolute growth

in the sector has been quite significant, nonetheless. It is difficult to provide statistics on transport modes separately for urban areas, but it can be speculated that certain types of transport are typical of urban areas and that their number has been increasing. The growth of transport facilities has been more significant in Dhaka. Thus the number of vehicular transport in Dhaka has increased from 35,458 in 1971, to 80,603 in 1981 and 182,366 in 1988 (CUS 1989b).

Table 6

The Growth of Vehicle Ownership in Dhaka City, 1971-1988

Type of Transport	1971	1981	1988 up to 31.7.89.
Car/Motor	12,205	22457	31932
Auto-tempo	–	454	2148
Bus	1531	3698	4860
Truck	3640	7657	10944
Auto-rickshaw	3843	6785	11066
'Mishuk' (Light auto-rickshaw)	–	–	800
Motor cycle	9644	28376	62539
Wagon/minibus	681	2398	7675
Jeep	2804	6090	7311
Others including trailer; pick-up van etc.	1110	2688	43485
Total	35458	80603	182366

Source: Dhaka Metropolitan Police, Quoted in CUS, 1989b.

The number of non-motorized urban transport, particularly, rickshaws, has increased even faster. Thus, in Dhaka city alone, there are now about 90,000 officially recognized rickshaws while possibly some 150,000 rickshaws are actually operating on the streets of the city. The estimated number of rickshaws was only about 50,000 (both licenced and unlicensed) in 1980 (DMAIUDP 1981).

The odd mix of varieties of modal types of transport, create problems of traffic management on the city streets. However, other factors also contribute to the transportation problem in cities. Due to resource limitation and unwise decisions, the government allows reconditioned vehicles to be imported. These vehicles become obsolete within a short span of time. There is also a large number of other old vehicles. Due to slack enforcement of regulations of vehicle fitness and air pollution control measures, these old vehicles are allowed to cause enormous degree of air pollution in the urban environment. Traffic problems are also the result of careless or untrained driving and of the mix of motorized and non-motorized vehicles on the same roads. The design capacity and surface quality of streets are also partly responsible for traffic problems and accidents in urban areas.

The problems of urban transportation are also manifest in the high fare cost compared to the income level of people. The cost of motorized transport is partly due to the high cost of fuel and partly due to the profit-making attitude of owners. The cost per unit distance of a rickshaw ride is also very high and remains usually beyond the affordability of the lower 40 per cent of the urban population. Thus for example, it has been evident from several studies that no more than 5 per cent of the poor in Dhaka ever use the rickshaw as a normal means of transport (CUS 1989b).

The role of the rickshaw in the urban transportation system in Bangladesh must be separately highlighted. It is the most conspicuous and most important urban transport mode. It has both positive and negative aspects. On the positive side are:

- It provides easy and quick employment to a very large number of the unemployed poor males.
- It is locally manufactured.
- It requires no mineral fuel and thus saves on fuel import.
- It causes almost no air pollution.
- It causes very little wear and tear of the road surface.
- It provides income to the local urban authority in the form of licence fees.
- In the absence of a proper alternative, it is a fairly acceptable transport mode for the urban middle class.

Some of the major negative aspects of the rickshaw may be listed as follows:

- It is an expensive mode of transport and can only be used for short hauls.
- It takes a lot of road surface space and thus creates traffic congestion.
- It tells upon the health of the driver and exposes him easily to hazards of air pollution caused by motorized vehicles and
- It is a vehicle of exploitation of drivers by owners and other involved agencies, including the municipal and police personnel.

It has been rather difficult to decide on the future prospects of rickshaws as a transport mode in the metropolitan areas, especially Dhaka. Obviously, transport planning and urban environmental planning have to consider both the positive and negative aspects of the mode.

Environmental and Utility Services

The quality of the urban environment depends largely on the quality of the basic urban utility services like sewerage, sanitation, drainage, garbage disposal, drinking water supply, electricity and cooking fuel. In an urban area of any developing country, the adequate provision of these services is a most demanding task. In Bangladesh, where urban population growth is so rapid, management skills inadequate and resources limited, the provision of services quite understandably remains unsatisfactory.

Drainage and Flooding

Due to rapid urbanization and unplanned or unregulated urban development, many of the large urban centres in Bangladesh now suffer from problems of poor drainage and consequent stagnation of rainwater. The situation is probably the worst in Dhaka, where major arterial roads and commercial areas in both old and new town locations, experience storm and rainwater stagnation. Unwise filling or closure of natural and artificial drainage canals has further aggravated the situation. The case of Dhaka is again pertinent. The city now suffers from inadequate drainage of storm water as well as

from river flooding. However, since the abnormal floods of 1987 and 1988, steps have been taken to protect the city from river water flooding by the construction of an embankment around it. The project is tremendously expensive and its impact on the future environment of the city remains to be investigated and assessed. However, one can easily say that haphazard urban expansion has played a major role in the aggravation of damages by floods. In the 1988 floods, nearly two-thirds of Dhaka metropolitan area was inundated. As urban development did not make adequate consideration for such a hazard, the damages to property were high.

Sewerage and Sanitation

The sewerage and sanitation systems in the urban areas of Bangladesh are far short of modern standards and even where the modern system of sewerage has been established, it is at best, inadequate in coverage. The human waste disposal system is a mixture of several modes, including the traditional mode of bucket latrines. Even in Dhaka city, only about 35 per cent of households have access to the sewerage lines and a very large percentage of the capital city's population do not have access to any sanitary latrines (CUS 1989c). In Chittagong, only 38 per cent of the population were served by septic tanks in 1985, 4 per cent by pit latrines, almost 30 per cent relied on bucket latrines, 5 per cent used communal latrines and 19 per cent used open latrines, while 4 per cent had no specific sanitary facilities at all (CUS 1989c, based on DPHE data).

The conditions in district and upazila towns are even worse (Table 7). According to the Department of Public Health Engineering, no water-borne sewerage system existed in any of the district towns in 1983 (CUS 1989c). According to the Department, only 12 per cent of the people of district towns used septic tanks, 10 per cent used pit latrines, and 5 per cent used bucket latrines, while 68 per cent used either surface latrines or no specific facility. In the upazila centres, only 4 per cent have access to septic tanks, 5 per cent to water seal latrines, 56 per cent use surface latrine and 35 per cent have no specific facility (CUS 1989c).

The high cost of installation of proper sanitary facilities, the cost of maintenance, lack of adequate space for installation and other factors stand in the way of improvement of the sanitary environment in urban and also rural areas.

Table 7

Coverage of Urban Sanitation 1985-1986

Type of Urban Centres	Coverage by Sanitation Facility, as % of Total Population				
	Septic Tank	Water Seal Latrine	Bucket Latrine	Pit Latrine	Other
District towns (excluding Dhaka and Chittagong)	19	14	26	8	33
Municipal town (other than district towns)	6	7	26	15	47
Upazila centres	10	19	6	13	52

Source: CUS 1989c.

Water

The existing facilities for supplying water for drinking and other domestic purposes to urban areas in Bangladesh are too inadequate for the rapidly expanding population and also due to the fact that means of water supply like tubewells do not function properly (CUS 1989c). Water in the urban areas is supplied to the households in different ways (Table 8). The public or municipal water supply system is through:

- Pipe line and house connection and
- Street water hydrants or stand pipes. Many households have private tubewells. In addition, water is also collected from traditional (and often rather hazardous) sources, like rivers, ponds and wells.

The public agencies mainly cater to the needs of the larger cities and towns. Even in such cases, the official capacity of water supply is far below normal requirements. Even in Dhaka, no more than 50 per cent of the population have access to piped water (CUS 1989c). The rest get water from public and private tubewells or from ponds and rivers, Quite often, severe shortages in drinking water supply is experienced, as has been the situation in April 1989 in several locations in Dhaka (Bangladesh Observer, April 6, 1989). Rapid urban growth, densification of old city areas, poor management and consequent system loss and other factors are responsible for the

inadequacy of water supply in the city. Moreover, the drinking water supplied by even such authorities as Dhaka Water Supply and Sewerage Authority (WASA) are often contaminated by dangerous bacteria, worms and insects, as reported in newspapers and also in special studies (CUS 1989c.). The high incidence of water-borne diseases in the urban population is an indicator of the low quality of water in cities. The population in the numerous slums and squatters of the large cities are particularly susceptible to such diseases.

Table 8

Status of Urban Water Supply in 1985

(Population Served, in Per cent.)

Urban Centres	House Connection	Public Stand Post	Hand Tubewell	Other*
Dhaka	49	10	–	41
Chittagong	29	8	10	53
District towns	14	9	29	48
Upazila centres	4	–	25	71
National Urban average	24	7	17	51

*Other includes: Own source of piped water, private hand tubewell etc.

(Third Five Year Plan, 1985-1990, GOB 1985)

There are now several schemes and projects of the government with assistance from World Bank, Asian Development Bank, UNICEF and other agencies to improve the water supply system in urban areas of the country (CUS 1989c).

Policy Implications and Recommendations

From the discussion in the preceding sections of this paper, it is obvious that urbanization in Bangladesh in the recent decades has been characterized by a number of features:

- The rate of growth of the urban population has been extremely high.
- The high urban growth rate is primarily due to rural-urban migration and secondarily, due to high natural growth rate of the urban population and redefinition of urban limits.

- The urban population shows a tendency of concentration, with nearly half of the total urban population concentrating in only 4 or 5 largest cities. Dhaka, the capital city, is very much a primate city with over one-fourth of the nation's total urban population concentrated in the city.
- The urban population is overwhelmingly poor and at least a third of the population are extremely poor who are unable to satisfy even their minimum nutritional requirements. The urban poor were originally the rural poor who were pushed out from rural areas by deteriorating economic and environmental conditions.
- The urban environment itself is characterized by unregulated and unplanned development and by inadequate access to land and housing, to transport facilities, to sewerage and sanitation services and to water. The other socio-economic facilities are also highly inadequate.

In short, the problems of urbanization and the problems in the urban habitats in Bangladesh have been rather critical.

How has the government viewed the problems of urbanization? What has been its policies regarding the urban environment ?

The government does not have a clear cut policy on urbanization or on human settlements in the country. However, there have been a few specific policy measures which indirectly affect the trend and characteristics of urbanization and urban growth. There have also been some direct but only segmented measures in the form of urban development projects and schemes as evident from the Five-Year Development Plans, wherein projects are identified and financial allocations provided (Planning Commission, GOB 1973, 1978, 1980 and 1985). It has been alleged that, there has always been a conspicuous case of urban bias in the public sector investments (De Vylder 1979). Thus it can be shown that although urban areas contained only 7 to 15 per cent of the national population between the 1st and the 3rd Five Year Plans, the sector nevertheless enjoyed nearly fifty per cent of the total resource allocations in the development plans (CUS 1989a). However, it can also be shown that such unequal allocations in favour of urban areas only benefited a small section of the urban population, namely the affluent and the governmental sections, while the majority poor population and their

neighbourhoods were always deprived. Most programmes and projects designed for and implemented in the urban areas, primarily, kept the upper income groups in mind. This is particularly true in the case of access to land and housing, but also, in case of transport facilities, water and sanitary facilities, educational, employment and other services.

Some recent policy measures of the government seen to have been formulated keeping in view the key problems prevailing in the country. These measures attempt at:

- Alleviating rural poverty,
- Reducing the rural-urban migration flows and
- Reducing the urban concentration in the few large cities.

The measures of rural poverty alleviation taken over the last few decades have been varied and include:

- Rural Works Programme (RWP)
- Food for Works Programme (FWP)
- Integrated Rural Development Programme (IRDP)
- Area Development Programme
- Swanirvar Programme
- Rural Credit Programme through Grameen Bank and lately
- The "Operation Thikana" (Cluster Village Programme).

In addition, there have been numerous programmes promoted by the NGO's. All these programmes together, have only been able to make a marginal impact on alleviating poverty in rural Bangladesh (Rahman *et al.* 1988). Neither the governmental nor the non-governmental programmes aim at any major structural change. The policy undertaken in the 1980s by the previous government on decentralization of development administration through the upazila system was expected to achieve better results in reducing regional inequalities by wider distribution of development resources. However, once again, no major structural changes are possible through this policy and intra-regional social inequality may persist or even increase. Within the decentralized development, it is necessary to focus on the poor and on depressed areas. There should be special emphasis on making the

upazila towns and other small and medium sized towns economically attractive, so that migration flows towards major cities are reduced.

The special problems experienced within the urban environment require particular attention. The problem of urban poverty and slum and squatter dwellers have been recognized by the Government at the highest level, as evident from the Report of the Dhaka *Mahanagari Bastee Niroshan* Committee (GOB, Ministry of Land 1989) and the constitution of the Task Force on Social Implications of Urbanization in 1991 by the Interim Government (Planning Commission 1991).

However, what is needed is the formulation and actual implementation of effective programmes for the alleviation of urban poverty. Such programmes should essentially include employment generation and income enhancement activities as well as social uplift of the poor.

Similarly, the critical problems of urban land and housing need to be addressed with priority. Policy towards equitable access to land and housing should be adopted with special attention to housing the poor. Providing adequate utility services is expensive and difficult, but with innovative and participatory approaches, the cost can be greatly reduced. Examples of such approaches are available from Karachi, Jakarta, Hyderabad (India) and other Asian cities. A fairly successful model of providing infra-structural facilities in slums has been established in several municipal towns of Bangladesh with joint efforts of UNICEF-LGRD and local municipalities. The problem of urban transport also demands urgent attention. In the large cities, motorized transport, especially buses and minibuses, should be encouraged while private vehicles should be discouraged. However, stricter emission standards should be enforced and traffic management improved. In small towns, the rickshaw can continue to play a major role while minibuses can provide the much needed mass transport service in medium-sized towns. Transport planning should also consider the increased role of the bicycle.

Important elements in urban planning in Bangladesh should include consideration of greenery and water in the urban landscape. These are in the tradition of the urban environment and compared to many countries of the world, these are rather inexpensive to maintain. Trees and water vastly improve the ecological and visual quality of the environment. Another element to be carefully retained and further enhanced is the role of open space for cultural and political activities. The Central Shaheed Minar square in Dhaka has made immense contributions to the social, cultural and

political development in Bangladesh. The need for more such spaces in Dhaka and the other cities and towns should be well recognized.

Finally, in solving the problems of urban environment, it is essential that proper urban planning should be exercised and in this exercise, the elements of physical environment and ecological balance should be given proper importance. Fortunately, this need is now well recognized by the government, although actual implementation of planning activities may not be easy or even immediate. Above all, urban planning and development should be a combination of functional and creative thinking.

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CHAPTER FOURTEEN

ENVIRONMENT AND HEALTH

Bilqis Amin Hoque and M. Mozzammel Hoque

Introduction

Environment means surroundings, especially the material and spiritual influences which affect the growth, development and existence of a living being. Health is the ability to adapt environment or, if necessary, to adapt to it. Environment and health together are such a vast and complex topic that any effort to describe them is bound to be incomplete. The ways in which environment and health interact vary with each of their intrinsic and compounding factors such as water, sanitation, food, nutrition state, housing, hygiene practices, socio-economic and demographic characteristics, cultural awareness, available resources and affordability, living standard, geographical location, health level and other factors. The various dimensions of health and environment can interact on any sphere of our living. Any act which disturbs the balance between environment and health, can lead to undesirable physical, chemical or biological interaction between the two systems and hinder development activities. The World Health Organisation (WHO) says that health is more than an absence of disease; it is complete mental and physical well-being. In a modest attempt, we present an overview on environment and health according to the major health problems in Bangladesh.

Environment, Health and Health Problems

Although poverty is the underlying cause of health problems all over the world, it is likely that the existing poor environment and health subsystem significantly contribute to the poverty system and vice versa. A sharp distinction in the causes of death by country status is illustrated in Table 1.

Table 1

Causes of Death in Developing and Developed Countries

Causes of mortality	Developed countries	Developing countries
Infections	12%	40%
Circulatory disease	33%	15%
Cancer	15%	5%
Trauma	7%	5%
All others	33%	35%

Infection remains the most important single cause of mortality in developing countries, whereas in developed countries, circulatory diseases have taken over from infections as the primary cause of death (Fowler 1986).

The shift from the disease spectrum in the poor country to that of the rich country depends little upon the quality of health care (Michael 1986). It is almost entirely dependent upon social conditions and major interrelationships with environmental factors which improve with development. Improvements in water supply and sanitary conditions played a fundamental role in improving health in industrialized countries during the nineteenth century (Preston and Walle 1978).

The WHO estimates that 80 per cent of all diseases in the world are water-related. Lack of water and poor sanitation share major responsibility for disease, disability, loss of work and deaths (Basaran 1985). The faecal-oral infections are of the greatest public interest that better water supply and sanitation provisions may help to control (Caincross and Feacham 1983). Such diseases can be transmitted by any means through which faecal material can spread from one to another.

Many researchers have developed transmission models and shown parallel multiple transmission models in environments (Feacham, Graham and Timacus 1989). In Figure 1, a framework of common faecal-oral transmission modes is shown.

While it has long been known that faecal-oral infections can be transmitted by the water-borne route, particularly in epidemics, they can also be transmitted by contaminated food, utensils, hands (Khan 1982), and even clothes (Stanton and Clemens 1986), in other words, a variety of routes which are facilitated under conditions of poor domestic hygiene. Environment and health interact very closely to set the ground for this vicious circle, For example, anaemia may be caused by hookworm, due to inadequate sanitation, but it can also result from malaria or malnutrition (Caincross 1988).

Malnutrition has many roots such as inadequate food supply, limited purchasing power, poor health conditions and incomplete knowledge about nutrition. There is a need for certain basic commodities to ensure the optimum growth of the nutrition state. When growth deficits are prolonged or recurrent, the ground is set for a vicious circle of undernutrition, interacting with adverse environmental influences and pathogens leading to infection, further deterioration of growth and malnutrition. The relationship between infection and malnutrition is synergistic and both may sap the efforts of the individual to protect himself. Poor nutritional status reduces the individual's resistance to infection, so that not only is infection more common but also minor illnesses progress rapidly to become life-threatening. Recurrent infection and undernutrition are both indicators of an impoverished environment.

Although statistics concerning mortality levels and trends represent an incomplete picture of the overall health situation in developing countries, data from in-depth studies in limited areas tend to confirm the significance of diarrhoeal and respiratory diseases as major causes of death in childhood (Feacham, Graham and Timacus 1989). Some 80-90 per cent of deaths from water and food-borne diseases are accounted for by diarrhoea and dysentery and some 60-70 per cent of the deaths from air-borne diseases by pneumonia and bronchitis (Pallonie 1981).

Some reviews have concluded that children in the developing countries suffer between 0.75 and 1.5 billion episodes of diarrhoea each year (Snyder and Marshal 1982 and Chen, Rahman and Sarder 1980). Comparing

Figure 1

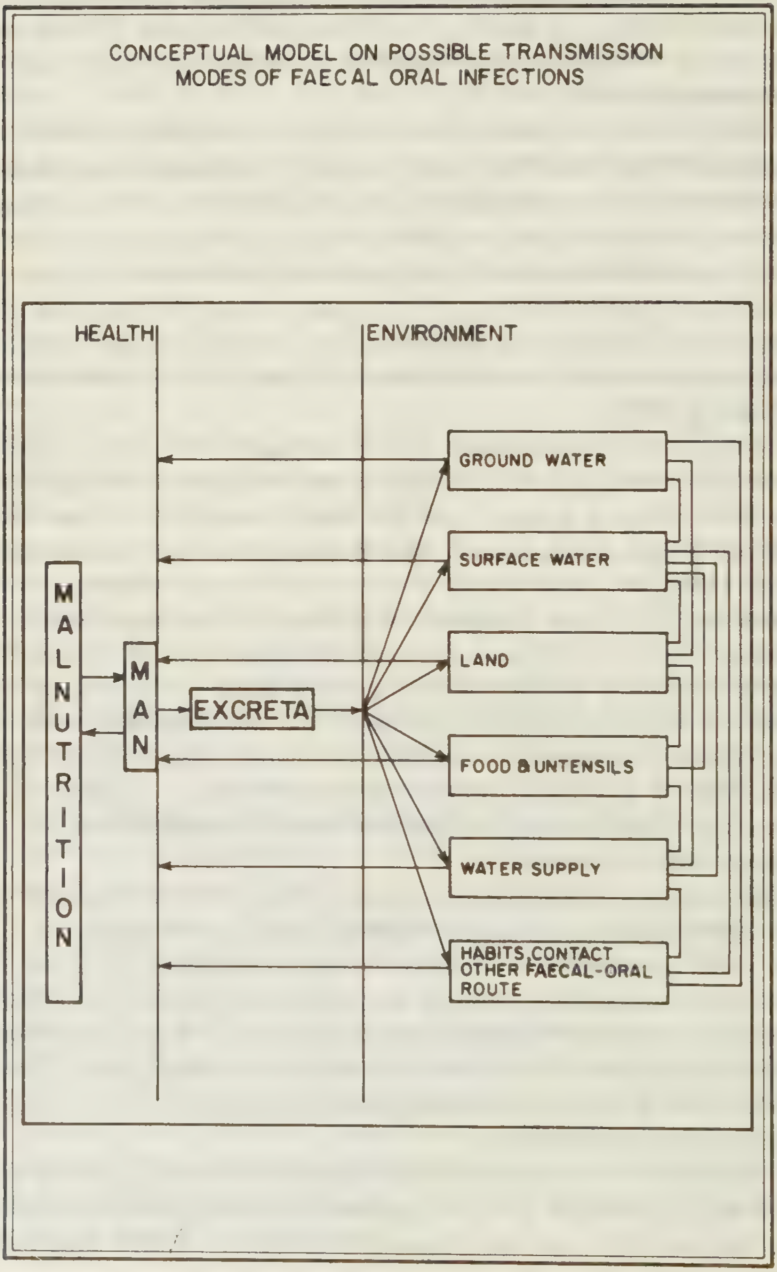

Fig - I

developing countries with the historical experiences of the developed world at comparable levels of mortality, it is evident that the significance of diarrhoeal mortality as a health problem has increased and it has not yet been alleviated by the application of medical technology (Preston 1976). As diarrhoea curative strategies have certain limitations, (Feacham 1986 and Fauva *et al.* 1990) preventive options have been suggested (Feacham 1986). Reduction in diarrhoeal diseases has been found to be significantly associated with preventive environmental options such as improving water supply and sanitation (Esrey *et al.* 1988, Aziz *et al.* 1989, Rahman *et al.* 1985, Evaluation Team 1989, Victoria *et al.* 1988) and improved hygiene practices (Khan 1982, Stanton and Clemens 1978, Sprunt 1973, Black *et al.* 1981 and Feacham 1984) in different parts of the world.

Communicable diseases, whooping cough, measles, neonatal tetanus and poliomyelitis kill millions of children and cripple or permanently handicap another million. The environmental health hazards, related to these diseases are excluded from this discussion, since immunization is a recognized preventive route. Without successful environmental health progress, any health program such as an immunization campaign, family planning or nutritional programs are very likely to experience severe barriers, as a child from a poor environment nursed back to health, can be reinfected within days. The countries with high infant mortality rates are often the countries with high birth rates.

The role of water and sanitation for the benefit of health is evident from the United Nations declaration of the 1990s as the "International Drinking Water Supply and Sanitation Decade" and its inclusion in strategies for primary health care in "Health for All by the Year 2000." A review of selected countries situation has indicated that majority of countries are likely to meet their targeted rural water supply coverage by 1990; however few will meet their rural sanitation coverage (Basaran 1985). Thirty per cent of the world's population do not have access to safe drinking water sources and more than 60 per cent do not have any sanitary provisions for excreta disposal.

Environment and Health in Bangladesh

Environment

Bangladesh, a country with one of the highest population density in the world, is situated in the east of the South-Asian continent and in the delta of

the mighty rivers, the Ganges and the Brahmaputra. Rivers cover about 8 per cent of the total area of the country even in the dry season. During the monsoon, another 29 per cent of the area is inundated and most of the remaining land is water-logged from frequent rainfall. Water plays a major role in the social and economic life of the country, bringing children and adults in almost daily contact with ponds, ditches, canals and rivers.

Surface water is abundantly available through the major part of the year for most people. It is used for domestic purposes such as cooking, bathing, washing and sometimes drinking. It is culturally preferable and often easily accessible and convenient. But it is heavily polluted with faecal matter. Coliform count of most of the surface water sources is beyond the acceptable standard for any domestic use (Rahim, Aziz and Islam 1985 and Ahmed 1988). Comparison of faecal pollution indicator values revealed that the quality of river-water fast deteriorated during the past few years (Ahmed 1988).

Bangladesh is one of those countries which is most likely to reach its rural water supply (by handpump) target set by the International Drinking Water Supply and Sanitation Decade. It has achieved one of the highest levels of service in any developing country, 45 per cent; based on 1 handpump to 75 people (Glenie 1985). However, the number of users per pump varies from few to few hundreds (UNICEF 1989).

Eighty two per cent of rural people use tubewell water for drinking, yet only 12 per cent claim use of tubewell for all of their water needs (UNICEF 1989). Since diarrhoea is a faecal transmitted disease, it is important that attempts are made to eliminate or minimize the magnitude of all possible transmission modes.

Major determining factors of handpump water use have been found to be distance (Ahmed and Smith 1987 and Hoque *et al.* 1989); family size and number of children (Hoque *et al.* 1989); privacy, tradition, convenience (Ahmed and Smith 1987); socio-economic status (Ahmed and Smith 1987 and Hoque *et al.* 1989) and quality or taste of water (Skoda 1979).

The high faecal pollution of surface water is associated with the habit of indiscriminate defecation practices. Less than 5 per cent of the rural population use sanitary latrines (UNICEF 1989). Open latrines are built on the banks of surface waterbodies or on low lands which are flooded in the monsoon season. Adults also use fixed places, bushes or fields. Children defecate in bushes, open fields or in the courtyards.

As people are little aware about the role of excreta in disease transmission, the same waterbody is used for domestic purposes, cleaning, washing clothes and defecation practices. A recent survey on sanitation showed that although 33 per cent of the rural population claimed use of a "fixed place" for defecation, only 34 per cent of them reasoned "health" for such use and 70-75 per cent said "to avoid embarrassment" (UNICEF 1989).

Health

Diarrhoea is the predominant cause of death among children below 5 years of age (UNICEF 1989, Survey Report 1985 and Report on National Goitre Prevalence Study 1981). The infant mortality rate in Bangladesh is among the highest in the world. The Planning Commission estimate is 125 deaths per thousand live births. Other estimates put it as high as 136 deaths per thousand births (UNICEF 1989). The cause-specific proportional mortality rates according to different age-groups, according to a country-wide survey (Brown, Brown and Becker 1984), are given in Table 2. As expected, the diarrhoea rates varied with age and except in infants, diarrhoeal diseases (watery diarrhoea and dysentery) is the major cause of death in all age groups, accounting for the highest cause, (29.2 per cent) of all deaths among children below 5 years.

Table 2

Cause-specific Proportional Mortality Rates According to Ages

Cause of death	0-<12 months rate	1 year -<5 years rate	0-<5 years rate
Watery diarrhoea	8.8	22.5	13.9
Dysentery	4.41	33.8	15.3
Infection	17.6	10.0	14.8
Tetanus	41.9	1.25	26.85
Measles	1.47	3.75	2.32
Others	25.73	28.75	26.85

Malnutrition is an associated contributing factor in most child deaths in Bangladesh (UNICEF 1989 and Basaran 1985). Severely malnourished children in Bangladesh have been found to be four times more likely to die of diarrhoeal diseases than those with an adequate nutritional status (Brown, Brown and Becker 1984). The proportion of population with calorie intake of 2,100 per capita per day is around 18 per cent (Fitzroy 1988). Vitamin A deficiency is a serious child health problem and one million people suffer from night blindness (Basaran 1985).

Environmental Intervention Studies

Hardly any study has been conducted at the national level to evaluate the health impact of environmental intervention efforts (UNICEF 1989). However, some environmental intervention research has been undertaken and the results are presented.

As part of a health impact evaluation of an environmental intervention project in rural Mirzapur (Aziz *et al.* 1989), diarrhoeal morbidity was recorded in children 0-4 years age, using the weekly recall method, in household interviews. The study was conducted in two similar socio-economic and demographic areas, one intervention and the other control, each having about 4,800 people. The intervention area was provided with 1 handpump for every 31 people on average, one double-pit latrine for every household and an extensive hygiene educational program. The control area was not provided with any of these facilities. During the post-intervention period, significant behavioural changes were observed in water-use and latrine-use. Majority of the people used handpump water for most of their domestic purposes. Some 43 litres per capita per day of handpump water were used. More than 90 per cent of the adults used latrines. In the control area, surface water was used for most domestic purposes, except for drinking. Less than 5 per cent of the households used sanitary latrines.

Table 3 shows the diarrhoeal morbidity experienced in the intervention and control areas. During the baseline year (pre-intervention period), the diarrhoeal morbidity experienced in the two areas was very similar, (3.85 and 3.75 episodes per child per year). Over the study period, diarrhoeal incidence rates declined in both intervention and control areas, but significantly more in the intervention area, for example, the rate was 61 per cent in 1987 and 83 per cent in 1984, the incidence density ratio was about 0.75 in each year

from 1985 to 1987. In other words, the children in the intervention area experienced 25 per cent fewer episodes of diarrhoea than those in the control area. The strongest impact of the project intervention was apparent in the percentage of days with diarrhoea, which remained constant in the intervention area but nearly doubled in the control area.

Table 3

Diarrhoeal Morbidity by Intervention and Control Area

Year	1984	1985	1986	1987
Diarrhoeal incidence, episodes per child per year				
Intervention area	3.85	2.72	2.18	2.34
Control area	3.75	3.59	2.98	3.12
Incidence density (Intervention/ control)	1.02	0.75	0.73	0.75
Per cent days with diarrhoea				
Intervention area	8.8	9.7	9.1	9.5
Control area	8.9	14.1	16.8	17.5

Significant health impact of environmental intervention was also reported from a Water and Sanitation Project at Teknaf, a rural area, geographically and culturally different from rural Mirzapur (Rahman, Rahman and Aziz 1985). In two villages of the project, 2,471 infants were followed-up for a year to study the health impact. Neonatal and post-neonatal mortality (PNNM) rates in the study cohort were 100 and 75 per 1000 live births. Risk of post-neonatal mortality in the household which did not use latrines was 3.12 times ($p < 0.01$) higher than in households which did and 1.5 times ($p<0.05$) higher in households with 10 or more persons than in smaller households. Post-neonatal mortality in the household which did not use tubewells (handpumps) water was higher, but not significantly so, than those which used tubewell water for all purposes.

The secondary infection rate of shigellosis was significantly interrupted by handwashing with soap and water, even under unsanitary conditions (Khan 1982). The secondary infection rate was 10.1 per cent in the study

group and 32.4 per cent in the control group. The secondary case (symptomatic) rate was 2.2 per cent in the study group. Therefore, handwashing seems to be an effective and cost-effective alternative when a practical solution is needed.

An educational intervention, to improve water-sanitation behaviour such as lack of handwashing before preparing food, defecation in the open by children in the family compound and lack of proper disposal of garbage and faeces, reported 26 per cent protective efficacy ($p < 0.0001$) of diarrhoea rate in children (Stanton and Clemens 1978). During the six months after the intervention, the rate of diarrhoea (per 100 person-weeks) in children under six years of age was 4.3 in the intervention communities and 5.8 in the control communities.

So far, we have discussed the environment and health mainly in the perspective of diarrhoeal disease, the major cause of morbidity and mortality in Bangladesh. But the relation between diarrhoea and malnutrition has often been an issue for debate (Aziz *et al.* 1989). A socio-environmental study on determinants of malnutrition and morbidity in rural and urban Bangladesh found that rural children were taller and heavier than those living in slums (Fitzroy 1988). Boys in both areas were better nourished than girls. It is also observed that despite their better nutritional status, rural children experienced higher prevalence of diarrhoea than their urban counterparts. The study concludes that to improve nutritional status, the strategies are: (i) increase access to food, and (ii) increase utilization of food available by reducing infections and these must necessarily include concern about inefficient food supplies.

Endemic goitre is considered to be one of the main nutritional diseases, prevalent in the country (National Goitre Prevalence 1981). The national prevalence rate was found to be 10.5 per cent in a study conducted in 417 locations with 214, 608 people. The endemicity varied with location, highest prevalence rate (26 per cent to 30 per cent) in the northern part of the country. Floods, cyclones and other natural calamities in the country are likely to cause variation in the iodine content of the soil. Besides iodine deficiency, which is the single most important cause of goitre; moderate temperature, congenial humidity, economic stress causing food deficiency and inadequate diet of protein and local vegetables are further risk factors for goitre. Iodination of salt was found to be the most cost-effective form of iodine prophylaxis.

Nutritional blindness due to vitamin deficiency has been recognized for many years as a serious health problem, with over an estimated 600,000 children suffering from night blindness in rural Bangladesh (Cohen *et al*, 1985). Age, sex and socio-economic status were indicated as risk factors. Households with a small garden, for example, even less than half the area of the main living accommodation, had far fewer night-blind children. ($p<0.10$).

Other than the goitre studies, a few other studies have shown effects of environmental trace elements on health in Bangladesh (Skoda 1979 and Briend, Hoque and Aziz 1990). High iron content in water has been found to be associated with higher diarrhoea incidence, as it restricts tubewell water use (Skoda 1979). Recent studies show that children below 5 years, drinking water from tubewells with water having high iron content, have significantly better linear growth than children drinking water with lower or no iron content even when controlled for age and socio-economic status (Briend, Hoque and Aziz 1990).

Identification of Problems and Priorities

We have presented evidence of the existing undesirable interaction between environment and health. As in most developing countries, the data base is weak. However, the urgent need for improvement in environmental health factors cannot be denied. Unsafe environment and health are the tolls to be paid not only by individuals, but also by families, communities and ultimately, the country.

Diarrhoea, a health problem, commonly found to be associated with poor environmental factors, is the major cause of morbidity and mortality. Faecal matter is the predominant cause of environmental pollution. Lack of health and hygiene awareness further tilts the balance between environment and health and allows for more possible transmission modes of pathogens. Therefore, environmental health issues of the country exist primarily at two levels: (1) Health effects from biological pathogens, and (2) Convenience, efficiency, aesthetics and acceptance of the controlling measures. Isolation and disposal of human sewage, provision of safe water and hygiene awareness campaign are usual recommendations to control the health effects. Experience from Bangladesh supports the efficiency of such interventions. Achievement of the level of environmental improvements provided in the

stated studies are hardly feasible in any short-term plans. But safe water supply and sanitation have major roles to play in the child survival revolution. Handpump and latrine installation should progress as fast as possible. Short-term plans may include education on environmental health, hygiene and effective use of the available environmental facilities. This complex environment and health situation has to be dealt with through careful long and short-term plans.

At the second level of environmental issue, efforts have to be taken to make the first level provisions acceptable, adoptable and appear useful to people. Success of first level attempts will depend on a number of factors. For example, diarrhoea incidence has been found to be higher in areas where tubewells have higher iron content (Skoda 1979). For various reasons, people refrained from effective use of the tubewells. It is important to realize that the environment and health subsystem deal with human beings who are influenced by convenience, tradition, culture and perceived logic. The long-term or short-term benefits will only be possible if they feel a need for it. Community participation at every phase of an intervention program: planning, decision-making, implementation, evaluation and dissemination should be made an integrated part.

The answer to the question as to what can be done about malnutrition, is more problematic. The per capita income is not likely to increase enough, within a generation, to solve the problems of the currently malnourished multitudes. The benefits of increased food supply through increased food production is less likely to reach a major portion of the population; the landless or farmers with very small landholdings, low-income groups or unemployed people and slums dwellers. If resources are made available to the health system, feeding programs and vitamin and mineral supplements can be provided through the health centres. Nutrition education is the most potential option in the short-term programme. Immunization, diarrhoea reduction and other steps to improve the general state of health also could have favourable effects on vitamin deficiency (Darnton-Hill 1989) and nutrition status (Fowler 1986).

Lastly, multi-dimensional research should be addressed for further definition of environmental risk factors for major health problems and development of appropriate techniques, technology and methods of communication.

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CHAPTER FIFTEEN

TECHNICAL REVIEW OF THE BANGLADESH FLOOD ACTION PLAN*

Leonard Sklar and Mujibul Huq Dulu

Introduction

Bangladesh is one of the most flood-prone countries in the world. Located on the flood plain delta of the major river system of the Ganges-Brahmaputra-Meghna Rivers, floods inundate 20 per cent of the national territory in an average year. The annual river floods are essential for the agricultural system of Bangladesh, yet in bad years, river floods cause widespread damage and social dislocation. To compound the river flooding problem, cyclone driven storm surges can sweep out of the Bay of Bengal causing coastal flooding, often resulting in huge losses of life.

Bangladesh is also a densely populated country, which currently must import food to meet the nutritional needs of its people. Much of the agricultural potential of the country remains unfulfilled. Bangladesh receives considerable foreign development aid, much of it aimed at the twin problems of food and floods. The World Bank's Bangladesh Flood Action Plan (FAP) proposes to address both the flood problem and the food problem through a

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*Condensed version of a draft paper. Printed with permission of Leonard Sklar, Research Director, International Rivers Network, Berkeley, California, USA and Mujibul Huq Dulu, on behalf of Bhuapur Development Project Service Civil International, Bhuapur, Tangail, Bangladesh, January 1992.

program of structural flood control measures which would alter the fundamental physiographic character of Bangladesh.

The natural forces confronting any structural flood control scheme are tremendous. Huge rivers whose channels migrate across the landscape, large earthquakes and cyclone driven tidal waves, all threaten to defeat the intentions of ambitious engineering works. Serious socio-economic obstacles must also be overcome if the FAP is to be built. Millions of Bangladeshis will be forcibly displaced and traditional farming and fishing practises altered permanently.

Large scale flood control projects in Bangladesh have a poor record in dealing with both the physical and social problems which can arise. It is essential that all the technical and planning issues be dealt with carefully and all potential alternatives considered, before any work begins on the FAP construction. Otherwise, Bangladesh may remain far from solutions to the flooding and food problems, while valuable resources are squandered in a vain attempt to remake Bangladesh in the image of another land.

The Geographic and Cultural Context

The Watershed

Bangladesh lies at the downstream end of a major river system where three large rivers, the Ganges, Brahmaputra and Meghna join together and empty into the Bay of Bengal. Together, these rivers pass 1,360,000 million cubic metres of water in an average year, second on Earth only to the Amazon River (Rogers *et al.* 1989). The entire drainage basin covers 1,760,000 square kilometres, including parts of India and China (the Autonomous Region of Tibet), and all of Nepal, Bhutan and Bangladesh. (Islam 1989). Bangladesh itself makes up only 8 per cent of the watershed, downstream of all other countries. Over 500 million people inhabit the drainage basin (Rogers *et al.* 1989).

The river system is far flung; rainfall runoff reaches the river mouth from as far as 2,400 km. to the west and 800 km. to the north (Rogers *et al.* 1989). The Ganges River rises on the southern slope of the Himalayas, flowing eastward through the densely populated and agriculturally productive Gangetic plan. The Brahmaputra, born only a few dozen kilometres from the Ganges across the Himalayan divide, drains the northern slopes flowing east

then south through one of the world's deepest gorges. The third major river, the Meghna is far shorter but drains the hills in Eastern Bangladesh, where some of the heaviest recorded rainfalls occur. For comparison, the combined river system of Bangladesh carries 2.5 times as much water as the Mississippi River in the U.S. while draining an area only half the size (Rogers *et al.* 1989).

The Delta

Over the years these rivers have formed a vast delta, the youngest and most active delta in the world. The modern nation of Bangladesh is made up almost entirely of delta flood plain. The delta has been forming for millions of years from the sediment eroded from the great Himalayas and Tibetean Plateau. The annual sediment load of the combined river system is estimated to be 2.4 billion tons of cobbles, sand and silt (Rashid and Paul 1987). Spread across the delta during river floods, the sediments are now 12 km. deep, extending in a fan 1,000 km. wide beneath the Bay of Bengal as far as 3,000 km. south, beyond Sri Lanka (Rogers *et al.* 1989).

When the rivers reach the flat delta of Bangladesh, they branch out to form many distributary channels, each carrying some flow to the ocean. Including the distributary channels, there are over 250 rivers in Bangladesh (Boyce 1990). The major rivers are huge. The Brahmaputra, known locally as the Jamuna, is 10 km. wide where it nears its confluence with the Ganges (Coleman 1969). A braided river channel, the river flow meanders around thousands of sand bar islands known as *chars*. Together, the *chars* of the Jamuna are home to more than 1.5 million people (Counseller and Dulu 1990).

The Nation of Bangladesh

Altogether 80 per cent of Bangladesh's 144,000 sq. km. area is flood plain; half the country is less than 8 m. above sea level (Brammer 1990a). With a population of 115 million, Bangladesh is one of the most densely populated countries in the world, with 800 persons per square kilometre (Ahmad 1989). At least 75 per cent of the population live in the rural flood plain areas, engaged in farming and fishing (Dalal-Clayton 1989). Bangladesh's

per capita income of US $180 causes it to be dependent on foreign assistance (Rogers *et al.* 1989).

Hydrology

The region's climate is dominated by the monsoon rains which drop 85 per cent of the year's rainfall in the 4 month period between June and September. Across the watershed the average annual precipitation is 1,500 millimetres, with the wettest part being Bangladesh itself. The coastal areas of Bangladesh receive an average of 3,000 millimetres of rain annually while the eastern hill areas have recorded 5,000 millimetres in some years (Rogers *et al.* 1989). In most years peak flows in the three major rivers do not coincide; the Meghna peaks first in June, followed by the Brahmaputra in July and the Ganges in August or September. In an average year, each of the rivers will overflow its banks, spreading shallow flooding over 20 per cent of the entire country (Brammer 1990a).

Agriculture

Bangladesh's farming practices have developed to take advantage of the seasonal cycle of flooding, which with year-round warm temperatures allows three distinct growing seasons. Rice is the primary staple crop, with jute an important export crop and wheat, vegetables, and other minor crops grown in the dry winter season. Three kinds of rice are grown, one in each of the growing seasons. The quick-growing *aus* variety is planted in April and harvested in early July, taking advantage of the pre-monsoon rains, but must be harvested before flooding occurs. *Aman* is planted at the onset of the monsoon flood in July and early August and harvested in November at the beginning of the dry season. *Aman* is a floating, flood-tolerant type of rice, able to grow up to 15 cm. in 24 hours to keep pace with rising flood waters (Islam 1989). With the development of dry season irrigation, primarily with tubewells and low lift pumps, it is now possible to grow a third rice crop called *boro* during the dry season. Planted in December and harvested in April, before the onset of the monsoons, *boro* production offers tremendous opportunity for increasing agricultural output in the future (Bangladesh Agricultural Research Council 1989).

Flooding in Bangladesh

Types of Flooding

The land of Bangladesh was created by flooding, and floods remain the dominant force shaping the landscape. There are four types of flooding in Bangladesh and each must be considered separately. In descending order of severity they are:

- Coastal floods which occur during the pre- and post-monsoon seasons are caused by cyclones which produce storm surges (incorrectly referred to as tidal waves) inundating large areas with saline sea water. Fierce winds combined with low atmospheric pressure and high tides can generate surges of up to 9 metres, causing tremendous loss of life and destruction of property. In a single event hundreds of thousands of people can lose their lives (Rashid and Paul 1987).
- River floods on the major rivers occur during the monsoon season due to heavy rainfall upstream and the snow melting in the summer in the Himalayas. These are slow moving floods, taking weeks for the rivers to rise and overflow their banks and lasting weeks more before the flood waters recede. In the unusual event that the major rivers peak simultaneously, flood waters can cover over half the country causing destruction of crops and property and dislocating rural populations for weeks at a time.
- Floods due to intense local rainfall occur during the monsoon season. The volume of rainfall often exceeds the local drainage capacity and remains ponded, sometimes for weeks and even months when drainage is exceptionally bad. Drainage can be blocked by road and railway embankments flood control embankments, or during high river flows when gravity drainage cannot occur.
- Flash floods are limited to the eastern and northern rivers and occur generally in the pre-monsoon spring season. Lasting no more than a few days, they are still capable of causing high water velocities which damage crops and property.

Priorities for Flood Hazard Reduction

If the first objective of the FAP is, as claimed, to *"safeguard lives and livelihoods,"* then coastal flooding due to cyclone-driven storm surges

should be the primary focus of the plan. Cyclones strike with much greater frequency than do destructive river floods, and are far more deadly. In the decade between 1960 and 1970 as many as 1 million Bangladeshis lost their lives to storm surge flooding, at least 300,000 of them on November 12, 1970 alone (Rashid and Paul 1987). By comparison, about 2,500 people were killed in the river flood of 1988, the worst of its type on record (Ahmad 1989). The most recent cyclone-driven flood struck at the end of April, 1991, killing at least 150,000 people, and causing extensive damage to livestock and coastal farms (Pearce 1991b).

Despite the scale of destruction caused by coastal floods, the FAP devotes only one of its 26 components to coastal protection, budgeting only \$70 million out of the first phase FAP budget of \$500 million (World Bank 1990a). Most of this sum would be spent on repair and lengthening of the existing coastal embankment which was not designed to protect coastal residents from these ferocious storms. Instead, this modest embankment was built to prevent normal high tides from inundating coastal fields with salt water, tides which rise no more than 3 metres. The wall of water which washed ashore in November 1970 was 9 metres above sea level (Rashid and Paul 1987).

River floods primarily damage property, while coastal floods cause great loss of life. By focusing on river flooding, the FAP has prioritized protection of property above protection of lives. Moreover, even in its focus on river flooding, the FAP betrays a lack of understanding of the essential role that river flooding plays in the agricultural economy of Bangladesh.

Benefits and Hazards of River Flooding

The English word for river flood has two equivalents in Bengali, *barsha*, the word used for normal beneficial floods and *bonna*, for abnormal destructive floods (Islam 1989). Bangladesh is as much dependent on floods as it is vulnerable to floods. Flood waters renew soil fertility by promoting algal growth which transfers up to 30 kgs. of nitrogen per hectare from the atmosphere to the soil (Rogers *et al*. 1989). Rotting vegetation and soil chemistry changes with intermittent inundation further renew the soil (Boyce 1990) In some areas, fine silts deposited by overbank river flows add phosphorus and potash (Rogers *et al*. 1989). Deposition of river silts also makes up for natural delta compaction, maintaining the cycle of subsidence and deposition.

Ground water reserves used for irrigation during the long dry season are recharged by the monsoon inundation. Ground water recharge also helps renew wetlands and lakes and the fisheries and wildlife they support. In normal years, the average of dry years and wet years, *barsha* river floods provide essential benefits that must not be overlooked in any flood control scheme. According to the authors of the USAID study, *"without the annual flood, Bangladesh would find itself in very serious economic and environmental straits."*

A *bonna* flood, or a destructive river flood, is either too much flood water during flood season, or floods which come earlier or later than expected, upsetting the finely tuned agricultural cycle. Early floods can wipe out spring *aus* crops before they can be harvested and late floods can disrupt the planting of the dry season crops (Rashid and Paul 1987). In extreme years of heavy rainfall and coinciding flood peaks on the major rivers, deep flood waters can force tens of millions of people from their homes for weeks at a time (Adnan 1991). Most take refuge on the high ground of road and railway embankments, bridge abutments and even flood control embankments (Ahmad 1989). Lives are lost, crops damaged, and productive activity disrupted.

Even the *bona* floods have beneficial aspects. In the flood of 1988, considered the most destructive on record, 14 per cent of the summer rice crop was destroyed (World Bank 1990b). However, total food grain production for that year set a record of over 15 million tons, due to a bumper harvest in the dry season which benefited from residual soil moisture left from the flood (Boyce 1990).

Bonna floods occur rarely; floods as severe as the 1988 flood are expected to occur only once in 150 years (Ahmad 1989). Despite the fact that the 1987 flood was also severe, there is no statistically valid evidence that flooding in Bangladesh has grown in severity over the last 100 years (Rogers *et al.* 1989). However, flood damages in economic terms have grown due to greater development and population growth.

Whether structural flood control measures such as FAP can successfully reduce flood damages is an open question. There are many unresolved technical issues which call into question the feasibility of constructing embankments capable of controlling the rivers of Bangladesh. The following sections will examine some of the engineering feasibility questions, the

socioeconomic impacts and constraints and some alternative planning approaches which may meet the needs of Bangladesh in a more cost-effective and reliable manner.

Engineering and Design Issues

Riverbank Protection from Migrating Rivers

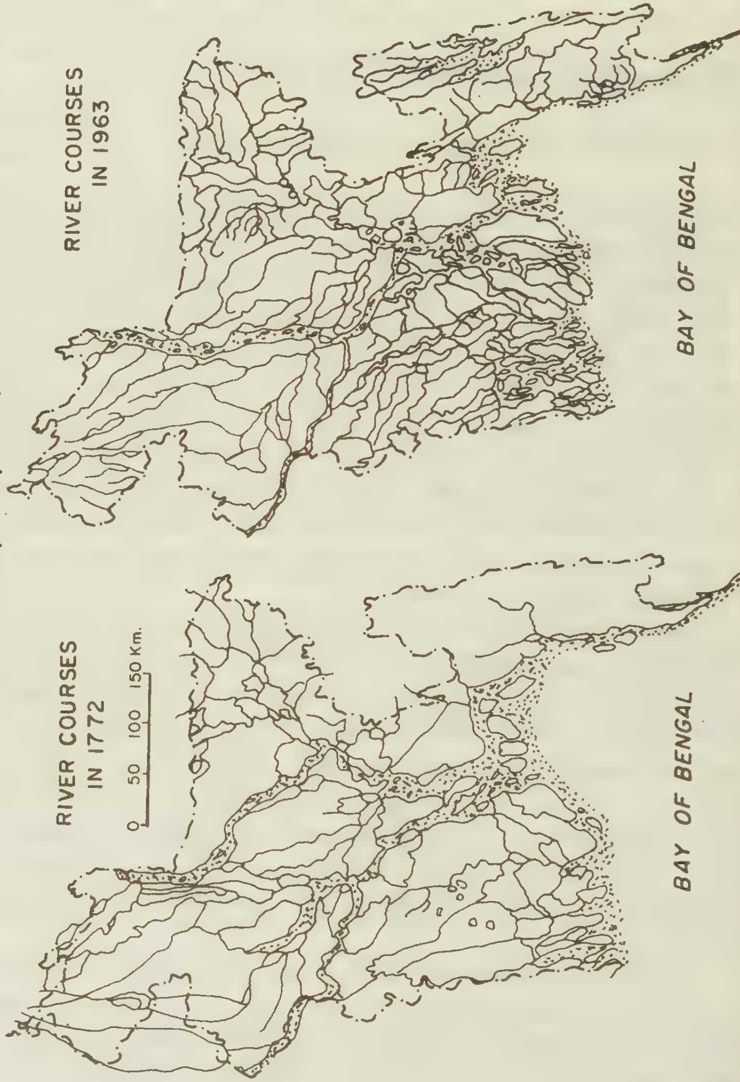
The rivers of Bangladesh are constantly changing their path to the sea, steadily chewing away their banks as they migrate left or right (Figure 1). The mouth of the Ganges River has shifted 250 km. eastward in the last 200 years, while the Brahmaputra is gradually moving westward (Dalal-Clayton 1989). During large floods, the shifts can be sudden and dramatic. In 1988, the combined Ganges and Brahmaputra moved 550 metres to the east, digging a new channel 45 metres deep. The embankment at Chandpur destroyed in this event was one of the best fortified in Bangladesh, protected by stone riprap lined groynes, so-called 'river-training' structures designed to deflect the current away from the bank. The river took no notice of these expensive defenses, washing away the structures along with half the town of Chandpur (Rogers *et al.* 1989).

The power of the river to erode its banks depends on the velocity of flow. With embankments confining the flow to the river channel, future floods will flow much faster, increasing their erosive power. Water which would have spilled across the flood plain will instead be concentrated between the embankments flowing deeper and faster, capable of carrying even more sediment. There are two approaches to protecting riverbanks from the force of migrating rivers; armouring the banks themselves, or planned retreat in which new embankments are built parallel to and behind the old embankments, without attempting to stop the advance of the migrating river.

Armouring embankments requires using materials which will not be moved by the highest velocity flows to which they will be exposed. Stone riprap of the type used at Chandpur is preferred due to its large size and heavy weight. However, there is very little stone available in Bangladesh since most of the country is made of alluvial sand and silt deposits (Rashid and Paul 1987). It would be impossible to line more than a tiny fraction of

Figure 1

COMPARISON OF RIVER COURSES IN BANGLADESH, 1772 AND 1963
(Hossain, et.al., 1987)



the planned embankments with stone. Instead, compacted earth must be used, or gabion mattresses, wire mesh boxes filled with earth, as suggested by the FEC study. In practice, these types of embankment materials, even with careful maintenance, have not been able to resist the tremendous erosive force of the fast currents of the flood swollen rivers of Bangladesh.

In order to protect earthern embankments from high velocity flows, river training groynes are used in an attempt to channel the main flow away from the banks. Groynes are armored earthern dykes aligned perpendicular to embankments, extending into the river channel itself. Most river-training groynes built in Bangladesh have proved unable to protect the banks behind them, washing away during peak flood flows. These failures generally occur after the groynes or embankments have been undermined by scour, a process where the riverbed on which the groynes or embankments have been built is washed out from below, as the deepest part of the river channel migrates toward the bank. To protect against scour, the foundation or toe of the embankment must be armored to a depth below the maximum possible depth of scour. This depth is often difficult to calculate in practice, but measured scour depths on Bangladeshi rivers range from 32 metres on the Brahmaputra to 45 metres on the combined Ganges-Brahmaputra to 53 metres on the lower Meghna, below the junction of all three major rivers (Dalal-Clayton 1989; Rogers *et al.* 1989).

Component 22 of the FAP includes a pilot river-training project, which will test various approaches to bank protection and groyne construction along the upper Brahmaputra. Unfortunately, the results from these tests may be inconclusive since the major floods which they will be required to control, may not occur for many years, even decades. Survival after normal floods by a test river-training structure does not assure survival after the more infrequent extreme floods.

Even if a successful method of protecting earthen embankments is developed, it will have to be used on both sides of the entire 3,500 km. length of the embankment scheme to prevent sudden channel shifts from cutting holes in the levees and allowing the river to chart a new course across the flood plain. Channel shifts take place when flood waters recede and newly formed sand bars direct the flow against previously secure banks. During large floods on the sediment laden Brahmaputra, giant dunes of sand migrate downstream; river bed forms as high as 15 metres have been observed moving at 600 metres per day (Coleman 1969). When and where

these channel shifts take place cannot be predicted but attempting to defend against them along the entire length of river is likely to be an impossible task. In the words of the authors of the USAID study, "*no embankments or river-training works in the world can control these forces if they are taken head on.*"

The other approach to preserving embankments in the face of rapidly eroding riverbanks is to construct embankments several kilometres back from the main channel, with a plan to move the embankments further back as the river migrates toward the embankment. This planned retreat is known as embankment retirement. When the World Bank set about rehabilitating the Brahmaputra Right Embankment in the 1970s, the engineers insisted on embankment retirement after examining the record of failed river-training and bank armouring at the site. However, despite repeated assurances by government officials, the land needed behind the embankment was never acquired. According to the World Bank's project audit, "*the loss of 800 hectares per year of farmland and urban real estate to the westward migration of the Brahmaputra cannot be accepted politically. Land is too scarce and the losers too well defined.*" Instead the government invested scarce resources on constructing new groynes to defend the embankment, which although ultimately unsuccessful did win political support for the government for its apparently valiant efforts (World Bank 1990b).

Not only were the landholders behind the embankments opposed to sacrificing their land to the retreating embankment, so too were the landless who had built their homes on the embankment itself, as well as the people who would be left unprotected on the river side of the new embankment. In practice, retirement, like maintenance, has only taken place in response to disastrous failures, such as the embankment now under reconstruction at the Meghna-Dhanagoda Irrigation Project. In 1988, the Dhanagoda River tore a 200 metre hole in an embankment protecting a \$50 million controlled irrigation scheme, destroying 40 sq. km. of High Yield Variety crops. The new embankment is set back 3 km. behind the old one (Pearce 1991a).

The FEC study sidestepped this important question of whether to build armored embankments close to the river channel, or set them far back and make plans to retreat when necessary. The French study team developed two scenarios, one with embankments setback 500 metres, another with setback of up to 5 kilometres. The wide setback scheme has political costs as well

as problems with land acquisition; at least 5,000,000 people will be displaced from land between the embankments, according to FEC study estimates.

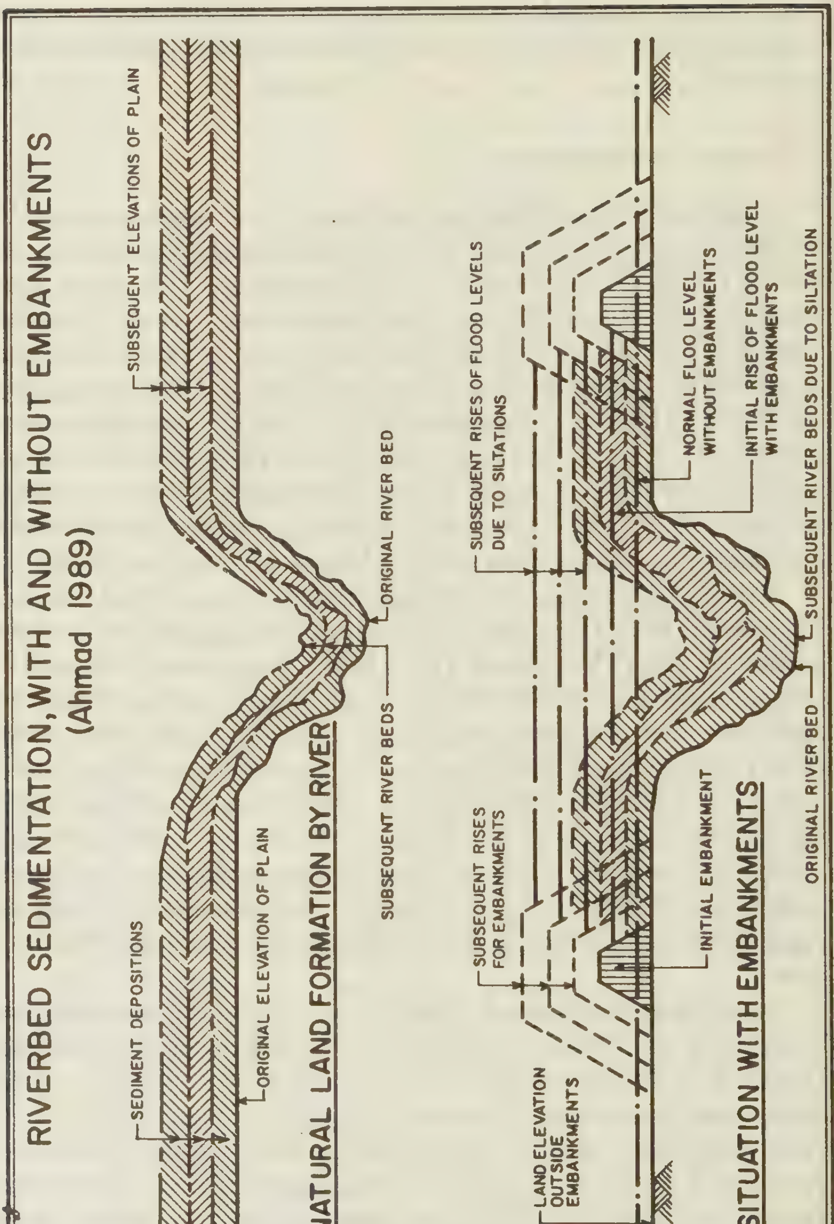
Riverbed Sedimentation

The combined Ganges-Brahmaputra-Meghna river system delivers 2.4 billion tons of sediment each year to the Bay of Bengal, ranking among the world's most sediment-laden rivers (Rogers *et al.* 1989). Even more sediment washed down from the rapidly eroding mountains ends up deposited on the flood plains during the annual river flood. With embankments confining the flow to the river channel, much of that sediment will instead be deposited between the embankments as the high monsoon flows recede (Figure 2). The riverbed and adjacent flood plain areas between the embankments will gradually rise as sediment accumulates. In order to maintain the intended flood control capacity, the embankments must continually be built up, rising higher and higher above the flood plain.

Riverbed aggravation between embankments has occurred on sediment-laden rivers around the world, including the Mississippi River in the United States and China's Yangtze and Yellow Rivers. In north-eastern Bangladesh, sedimentation between embankments on the Khowai and Manu Rivers have left those rivers 4 metres higher than the surrounding land. Water which flows through the frequent breaches in these embankments is unable to return to the river and must find another route to the sea. India's Kosi River, an embanked tributary of the Ganges, is perched 6 metres above the flood plain. As a result, parallel rivers have formed behind the embankments carrying the local runoff, while the river has been reduced to a raised aqueduct connecting the base of the mountains with the Ganges (Neill *et al.* 1988).

Dredging huge amounts of sediment from 3,500 km. or embanked rivers would be a very expensive undertaking. The US Army Corps of Engineers spends $10 million annually to dredge a few miles at the mouth of the Mississippi for navigation (Rogers *et al.* 1989). Neither the UNDP nor the FEC studies which proposed the embankment scheme seriously, considered dredging as a solution, apparently assuming periodic raising of embankment heights would be part of the maintenance program. The FAP document makes no mention of riverbed sedimentation.

Figure 2


RIVERBED SEDIMENTATION, WITH AND WITHOUT EMBANKMENTS
(Ahmad 1989)
SEDIMENT DEPOSITIONS
ORIGINAL ELEVATION OF PLAIN
SUBSEQUENT ELEVATIONS OF PLAIN
SUBSEQUENT RIVER BEDS
ORIGINAL RIVER BED
NATURAL LAND FORMATION BY RIVER
LAND ELEVATION OUTSIDE EMBANKMENTS
SUBSEQUENT RISES FOR EMBANKMENTS
SUBSEQUENT RISES OF FLOOD LEVELS DUE TO SILTATIONS
INITIAL EMBANKMENT
NORMAL FLOO LEVEL WITHOUT EMBANKMENTS
INITIAL RISE OF FLOOD LEVEL WITH EMBANKMENTS
ORIGINAL RIVER BED
SUBSEQUENT RIVER BEDS DUE TO SILTATION
SITUATION WITH EMBANKMENTS

As the riverbed rises due to sedimentation, not only will the embankments need to be raised, but so will every water control structure set into the embankments to allow controlled flooding and drainage. Such expensive modifications will be effective for a limited time but eventually gravity drainage will no longer be possible. Pumps will then need to be purchased and installed to remove rainwater from the fields behind the embankments.

While the riverbed and its embankments are rising, the land behind the embankments will be deprived of sediments formerly deposited by annual inundation and will gradually subside due to natural delta compaction. Eventually the riverbed will rise above the surrounding flood plain, with the embankments towering over the "protected" fields. The stage would then be set for a catastrophic flood should the river breach the embankments.

If the breach is wide enough and the slope toward the flood plain steep enough, the entire river may shift course leaving the embankment and raised riverbed high and dry, a spine of land winding through a flooded landscape. This abrupt channel shift would be only an unnatural acceleration of the natural process of channel migration on a river delta, where new distributary channels form to replace the old ones whose gradients have become too gradual. The risk of a channel shift may be greatest along the Brahmaputra, which according to the USAID study *"is now perched on a fan of its own silt deposits, perhaps ready for a further major shift, which must not be provoked by ill-judged works on the river."*

Earthquake Hazard

The Indian subcontinent is plowing into the Eurasian land mass at a rate of 5 cm. per year, pushing up the Himalayan mountains and the Tibetean plateau (Rogers *et al.* 1989). The tremendous energy stored in this land deformation is released in earthquakes which shake the delta, the most severe earthquakes occurring in the north-western Bangladesh where the first of the FAP embankments are to be built. The most powerful earthquake ever recorded on land occurred in this area in 1897, estimated at 8.7 on the Richter scale (Boyce 1990). The ground accelerations from powerful earthquakes produce instantaneous excess pore water pressure, or liquefaction, in the saturated soil base of river embankments, leading to cracking, spreading, flow failures and subsidence.

Since the embankment approach to flood control is a permanent commitment, it is a virtual certainty that a strong earthquake will strike this area during the life of the embankments. Should one occur during a severe flood, or even an average flood, the result could be a catastrophic flash flood across the "protected" flood plain. If a strong earthquake should strike during the dry season, it is likely that the scale of destruction would be so great that repairs would take many years, exposing upstream areas to the full force of the once banished floods.

Earthquakes are often associated with sudden shifts in river course. For example, an earthquake around 1800 caused the Brahmaputra to abandon its channel and cut a new course 100 kilometres to the west (Boyce 1990). Another sudden shift in course by the Brahmaputra in this area after construction of an embankment system could result in the river completely abandoning the multi-billion dollar flood control system.

Despite the threat posed by earthquakes, the World Bank's FAP document ignores the issue while the FEC study briefly mentions unspecified "special steps" which should be taken to protect the embankments.

Maintenance of Flood Control Embankments

The most important requirement for any successful embankment flood control program is careful and regular maintenance. Maintenance is required to repair erosion from the torrential monsoon rains and high water currents, as well as to make up for settlement due to saturation and any rise in riverbed elevation due to channel sedimentation. After the foreign contractors and experts have left, the Bangladeshi government will be responsible for carrying out the expensive and time-consuming maintenance work. For embankments on the lower Mississippi River in the United States, maintenance costs are $1 million annually for each mile of river (Rogers *et al*. 1989). The FEC study estimates that maintenance of the 7,000 kilometres of new embankments will cost Bangladesh at least $160 million per year.

The Bangladeshi government has a dismal record maintaining its existing embankments. According to the FEC study, maintenance has been *"badly neglected,"* a policy which will not be *"viable anymore"* after the multi-billion dollar FAP embankments are constructed. The UNDP study blames the *"total disinterest often demonstrated by the population to maintain the*

structures and works that are to protect their life and property. Unless this situation is changed fundamentally to the extent that people respect flood protection infrastructure and are willing to contribute to proper maintenance, the very purpose of building embankments and structures will be defeated."

In fact, it is the local people who are supposed to benefit from the embankments who intentionally cause the most damage to them. So-called "public cuts" are one of the most common types of embankment failures. Farmers often demolish sections of embankments in order to drain their fields of stagnant water which might otherwise pond for months. Others cut the levees to allow flood water to enter their fields and irrigate their summer crops during dry years (World Bank 1990b). In the case of the Brahmaputra Right Embankment, people who live on the unembanked left bank will breach the levee in the hope that flooding their neighbour's land will lower the flood waters back on their unprotected side of the river. One observer reports, *"vigorous arguments, sometimes ending in deaths, are not uncommon between people guarding or wishing to cut sections of embankment"* (Dalal-Clayton 1989).

Public cuts can be avoided when people living behind embankments are united in their commitment to maintaining the embankments. However, this occurs only rarely, such as the heroic community effort to save the Dhaka-Narayanganj-Demra Project embankments during the 1988 flood. In this case the protected area had become an urbanized suburb of the capital, despite having been designed as an agricultural flood control project (Islam 1989).

One unintended benefit of high embankments is the refuge they offer from flooding, especially for landless people looking for a home site. The Brahmaputra Right Embankment, which runs along 240 km. of the right bank of the Brahmaputra and its tributary the Teesta River, is a prototype for the planned FAP embankments. Nearly the entire length of the embankment is covered with the dwellings of over 100,000 people, who excavate the back slope of the embankment to form a flat surface on which to build their houses (World Bank 1990b). Not only does their presence make maintenance difficult but the excavations themselves weaken the embankments.

Urban flood walls have fared just as badly under the care of the Bangladeshi government. The Dhaka City flood wall is perforated with hundreds of broken erections, often knocked down to allow vehicle passage

or to drain standing water. The wall no longer provides relief from high flood waters but is effective in restricting drainage of ponded rainwater, which in the urban environment is often laden with sewage or industrial wastes (Adnan 1991).

Component 13 of the FAP will spend $300,000 over 5 years to monitor operation and maintenance of newly constructed embankments. Yet given the past record of failure to maintain flood control embankments, the entire FAP system rests on surprisingly optimistic assumptions about the ease with which this complex problem will be solved.

Drainage and Water Logging

One of the stated goals of the FAP is to create *"flood free land" and to minimize flood damages"* (World Bank 1990a). However, structural approaches to flood control such as embankments and compartments often have the reverse effect, trapping water which would otherwise drain off within the protected areas. Much of the water responsible for the flood problems of Bangladesh falls as rain directly on the affected areas rather than overflowing the riverbanks. When intense monsoon rains occur at the same time, rivers are cresting with upstream runoff, local rainfall cannot drain until the river flood peak has passed. With embankments in place, the flooded fields often are unable to drain, sometimes for months after the river flood peaks. For this reason, the public cut has historically been the greatest threat to embankments in Bangladesh

One researcher who studied this problem in detail found that more flood damages to crops occurred behind flood control embankments than in unprotected areas precisely because of obstructed drainage. (Stewart as cited in Rogers *et al.* 1989). During the severe floods of 1987 and 1988, the area which suffered the greatest losses to the wet season rice crop was directly behind the Brahmaputra Right Embankment, an area supposedly protected from flooding (Adnan 1991).

Long-term ponding of water behind embankments not only threatens crops but human health as well. Poorly-designed flood control works have been shown to assist the spread of malaria and other diseases. Water contaminated with sewage and industrial wastes, which would be carried away by the river if allowed to drain naturally, is instead held stagnant within the "protected" area (Dalal-Clayton 1989).

The complex system of compartments planned as part of the FAP is likely to compound the drainage problem. Designed to be flooded in a controlled way to irrigate wet season rice and jute crops, compartments must be drained either by control structures set into the embankments or by pumping water over the embankment walls back into the river. In practise, gravity drainage structures have been difficult to design correctly and maintain properly, and the large pumps needed are too expensive for most Bangladeshi farmers (Ahmad 1989). In one compartment scheme in *Beel* Dakatia, dysfunctional drainage systems led to either years of water logging, resulting in crop failures and thé loss of the area's trees. Without wood fuel for water purification, dysentery became widespread. By 1990, those who could afford to move away did, and thousands of those who remained rioted and breached the embankments to drain the land (Adnan 1991).

Flood Hazard Risk Reduction

All of the justifications for the FAP rest on the simple assumption that investing in structural flood control measures will reduce the risk of destructive flooding. Yet inherent in the plan are increases in flooding severity and frequency for large portions of the country, as well as substantially greater risks of catastrophic flooding for the areas supposedly protected by the flood control structures.

Embankments do not lessen the amount of water during a flood, they merely shift the flood waters from one place to another. The land between the embankments, as much as 300,000 hectares according to the FEC wide setback scenario, will certainly experience higher flood levels and greater flow velocities, making the land uninhabitable during the wet season. Between 5 and 8 million people currently inhabit islands and riverbanks in this area. During normal years, the concentration of flood waters between the embankments will produce peak flood water elevations equivalent to those of extreme floods without embankments.

According to the FAP, the construction of embankments will proceed from upstream to downstream, over the course of the estimated 20 to 30 year building period. As embankments rise along the upstream reaches, water which formerly was stored on the upstream flood plain will be transferred to downstream, aggravating flooding there. Normal floods will become deeper and more destructive. Exceptionally destructive floods will

occur more often, because the burden of the flood waters will be concentrated on downstream lands. The same process will take place during construction of the compartment project. Land not within compartments will be flooded to a greater depth by water excluded from upstream compartments.

In effect, decisions will be made during the construction process to flood some people's land in order to protect other's; decisions which are difficult to justify from both a technical and a political point of view. Given the record of uncompleted and poorly maintained flood control works in Bangladesh, there is a reasonable possibility that the FAP will never be completed as planned (Rogers *et al.* 1989; World Bank 1990b; Adnan 1991). In that case, the FAP will amount to a permanent transfer and concentration of the flooding problem to those downstream without local flood protection.

Even those fortunate enough to be protected by the upstream embankments and compartments will face a greater risk of someday experiencing a sudden highly destructive flood due to embankment failure. In normal years, flood waters spill over the riverbanks slowly as waters rise gradually, with ample warning for preparation and evacuation. The slow-moving water itself causes little damage or loss of life. With embankments in place, the same normal year flood will raise water levels. high against the embankments, and should there be a breach, a torrent of water would rush through the embankment, with great destructive force. As riverbeds arise due to sedimentation, and embankment heights keep pace, the risk will become greater.

The FAP fails to include the costs of increased flood damage downstream and greater risk of catastrophic flooding due to embankment failure. Careful sensitivity analysis must be applied to estimate the true net improvement in flood hazard risk which the FAP would produce. The analysis must be based on data from actual embankment projects in Bangladesh, not on idealized best-case scenarios for the future, and must be applied to the overall cost-benefit analysis for the entire project.

Social and Environmental Constraints

Compartment Operation

The World Bank's economic justification for the FAP rests primarily on increasing wet season agricultural production through promotion of High Yielding Varieties (HYV) of rice (World Bank 1990a). Although flood sensitive, HYV's still require large amounts of water to grow. With

embankments in place the necessary amounts of water could only be delivered to the protected fields by controlled flooding. FAP calls for construction of many large enclosed farm areas called compartments, or polders, each about 10,000 hectares, to facilitate controlled flooding.

Bangladesh has already experienced considerable operational difficulty with compartments built as part of externally funded combined flood control and irrigation projects. In the words of an internal World Bank audit. *"polder schemes had operational surprises after implementation. Farmers on relatively high land within the polders had a different view from farmers on the low lands as to what constituted a flood. Gate settings that were just right for the former would be disastrous for the latter. Similarly, farmers growing jute may need flooding at times when rice growers in the same polder do not. Gate operations were under the control of the most influential farmers. The need for organizing farmers numbering in the tens of thousands to set up equitable polder operations is one of the great drawbacks of the polder technology for wet season agricultural production"* (World Bank 1990b).

When polders have been built on relatively high land which normally experiences only shallow flooding, HYV's have been successfully grown without the drainage problems of lower land (Rogers *et al.* 1989). This is due in large part to the possibility of using gravity drainage to remove excess water. However, according to the audit, *"polder investments in deeply and moderately flooded areas, utilizing fixed pumps for drainage in the wet season, have not been a cost-effective way to address the flood problem"* (World Bank 1990b).

According to the FAP document, *"the compartment approach will require a higher standard of planning, design, construction and operation than has generally been practiced todate in Bangladesh"* (World Bank 1990a). FAP component 20 is a pilot compartment project which will test unspecified operational improvements. However, the fundamental problems constraining efficient and equitable compartment operation, such as unequal land distribution and instances of corrupt local government are not going to be solved by technological innovation.

Land Acquisition and Displaced Populations

A great deal of land will need to be acquired to build the huge embankment scheme envisioned by FAP, in one of the world's most densely populated

countries. Land will be needed on which to situate the embankments themselves; the material used to construct the levees must come from somewhere, probably vast "borrow" pits alongside the rising embankments; still more land will be required for the inner embankments making up the compartments and the canals and water diversion works which are supposed to regulate the controlled flooding. People will be forced to move from each of these areas. In addition, there are the people who live along the river and on the many river islands called *chars* who will be exposed to intolerably high flood levels even in normal years. This is precisely the reason the *char* dwellers of the Jamuna have brought the case against the FAP before the Second International Water Tribunal in the Netherlands in February 1992.

Estimates of the number of people who will be forcibly displaced from their homes range as high as 8 million (Counseller and Dulu 1990). World Bank guidelines for resettlement and rehabilitation of displaced people require that their livelihoods not only be replaced, but that displaced people should benefit directly from the project and enjoy a higher standard of living after resettlement (World Bank 1990c). Where will the land come from to compensate the displaced millions? Many of them, the *char* dwellers and embankment residents, for example, are living on the river precisely because there was no other land available to them.

Too often, the social costs of forced displacement of affected populations have been ignored in the planning of large scale water projects. Planning cannot be limited to technical issues but must take the social context into account. Failure to do so can lead ultimately to the failure of the project. A case in point is the World Bank financed flood control and irrigation project at Karnaphuli which has been stopped by organized opposition of poor peasant families. Begun in 1975 with 80 kilometres of planned embankments, only 17 kilometres were actually constructed by 1986 when the project had to be abandoned (World Bank 1990b).

Fisheries

The FAP threatens to virtually wipe out one of Bangladesh's most important natural resources; fresh water fisheries. Over 80 per cent of the animal protein consumed in Bangladesh is derived from fish (Dalal-Clayton 1989). For the rural poor fresh water fish are an essential food source; nearly 3 in 4 families engage in open water fish capture, fishing in rivers, lakes

and flooded fields. (Rogers *et al.* 1989). After jute, fish products have become the second most important export commodity earning Bangladesh badly needed hard currency (World Bank 1990b).

Fish spawn in the rivers and estuaries migrate during monsoon season to the flooded fields of the flood plain to feed and mature. When the floods recede, they either return to the rivers or to lakes and wetland depressions known as *beels*. Sixty per cent of the 251 identified species found in Bangladesh are flood plain dependent (Boyce 1990). Embankments threaten to cut off this vital habitat completely.

In addition, the loss of normal flooding may lower the ground water table in many compartmentalized areas, drying up important wetland *beels* and lakes. Pesticides and fertilizers required for high yield variety crops could also seriously degrade fisheries, both in flooded fields and in riverine spawning grounds.

Where embankments have been built in Bangladesh, fisheries have been badly hurt (Islam 1989). At the World Bank funded Chandpur project, a combined flood control and irrigation embankment scheme, a 1981 World Bank audit reports total loss of prawn and near total loss of fish production (World Bank 1990b).

The FAP proposes to mitigate the migration problem by designing fish passage structures which would allow movement to and from controlled flooded compartments (World Bank 1990a). However, such structures have been notoriously ineffective at moving water in and out of controlled compartments. Given the complexity of fish migration patterns, and the low level of scientific understanding, there is no sound basis for expecting embankment water control structures to serve as adequate fish migration routes.

Component 17 of the FAP is a fisheries study focused primarily on substituting closed water fish culture for open water migratory fisheries. Closed water refers to artificial fish ponds and hatcheries, as well as shrimp ponds already widespread in coastal areas. Despite this technology's potential for growth, it could never compensate for the species and habitat loss embankments would cause. Since open water capture represents 80 per cent of fresh water catch, closed water fishery production would have to double just to make up for a drop of 25 per cent in open water capture (Boyce 1990). The genetic inferiority of hatchery fish makes them more vulnerable to disease than their wild counterparts. Perhaps most important, transition

from open water capture to closed fish culture means privatizing a vital public resource, limiting access for poor rural Bangladeshis to an essential protein source.

Ecological Impacts

Bangladesh's wildlife would suffer from the transformation of the delta envisioned by the FAP. Vital wetland habitats would be threatened by loss of annual flooding. Many types of fish, reptiles including 25 species of turtles, amphibians and over 150 species of water fowl, are already in decline partly due to past flood control works. According to the International Union for the Conservation of Nature, one of the most important wildlife habitats in Bangladesh, the Chalan *Beel* has already been ruined as a result of flood control, drainage and irrigation projects (Dalal-Clayton 1989).

Recommendations

Solving the Food Problem

The core economic justification for the FAP is increasing agricultural production to feed the growing population of Bangladesh. The assumption is that with embankments protecting fields from uncontrolled flooding, Bangladeshi farmers will be able to shift to flood sensitive High Yield rice Varieties (HYV) during the wet season. However, the greatest potential increases in food production are not in wet season crops, but in dry season crops using the small scale technologies of tubewells and low lift pumps to irrigate otherwise dry fields (Rogers *et al.* 1989).

Tubewells are drilled wells with small pumps able to tap both shallow and deep ground water. Low lift pumps are able to raise nearby surface water from streams or rivers into fields and yet are small enough to be moved around to maximize their efficiency. Unlike large scale gravity-fed canal irrigation systems, these so called `minor irrigation' technologies allow farmers to apply exactly the right amount of water at the right time for their individual crops.

Currently Bangladesh utilizes only 25 per cent of its irrigation potential (Rogers *et al.* 1989). In the words of the USAID study *"the alluvial plains of the Ganges-Brahmaputra basin hold the world's largest reserve of fresh,*

annually replenished ground water." Tubewell irrigation costs around $1,000 per hectare irrigated, one third the cost of surface gravity irrigation and is about twice as productive (Rogers *et al.* 1989). In other words minor irrigation is six times more economical than surface gravity irrigation, the technology favoured in past large-scale flood control and irrigation projects. One important constraint on the expansion of tubewell and low lift pump irrigation is difficulty in obtaining credit, a problem which may be exacerbated by the huge expenditures of the FAP.

Flood control projects in Bangladesh have an exceptionally poor record in promoting increases in agricultural production. The largest project to date, the Brahmaputra Right Embankment, to be expanded by FAP, is a case in point. When the project was first designed, it was assumed that 26 per cent of the benefits would accrue from increases in dry season production, and 74 per cent from wet season HYV growth (World Bank 1990b). The embankment never succeeded in containing floods due to lack of maintenance and intentional breaches made by farmers trying either to water their fields in the winter or drain them in the summer. The World Bank project completion audit found that while crop yields had improved during the project period, 97 per cent of the overall increase in agricultural production had come from dry season tubewell irrigation (World Bank 1990b). Virtually no increase in wet season yields occurred despite the efforts to promote HYV's because of the failure of the embankment to stop the floods.

The fact the minor irrigation technologies were successful in the dry season, despite the flooding of the wet season shows the basic independence of minor irrigation from flood control schemes. According to the audit, there is an *"absence of statistics or studies to support the general argument that flood control embankments are critical for the adoption of dry season irrigation technology. It is quite likely that policies and factors other than those concerning flood control are more important for this development, particularly, the government's policies on financing and control of shallow tubewell installation"* (World Bank 1990b).

Structural flood control projects along the rivers of Bangladesh have not been successful in promoting either dry season or wet season agriculture. Again quoting from the World Bank flood control performance audit, *"flood control embankments subject to erosion from a migrating riverbed are poor investments for promoting wet season agriculture production because they cannot be made to work effectively"* (World Bank 1990b).

Over the long term, regularly flooded areas in Bangladesh, where most wet season crop losses occur, are equally productive as rarely flooded areas (Rogers *et al.* 1989). The less flood-prone areas may produce more in the wet season, but that advantage is made up by greater dry season production in the more flood-prone areas because of residual soil moisture. The marginal benefit offered by flood control embankments, if they can be made to work effectively, is still small compared with the dry season potential using minor irrigation technology. According to the National Water Plan, adopted by the Government of Bangladesh in 1986, minor irrigation investments yield 8 times the benefits in increased agricultural output as investments in flood control and drainage (World Bank 1990b).

Solving the Flooding Problem

Not only are structural flood control investments not the most cost effective approach to solving the food problem, as shown in the preceding section, they are also not a cost-effective way of solving the real flooding problems of Bangladesh. Solutions to the flooding problems of Bangladesh must be measured in reduction of flood damages and prevention of loss of life. Due to the engineering feasibility problems and socioeconomic constraints discussed above, it is likely that the FAP embankments will not successfully control the extreme river floods responsible for most river flood damages. Cyclone driven coastal floods will continue to cause huge loss of life long after the FAP is completed. Ironically, the FAP embankments are certain to disrupt the beneficial normal annual floods on which Bangladesh now depends.

Management of River Floods

A more cost-effective approach to solving the river flooding problem would be to invest in nonstructural flood management measures such as flood forecasting and warning, flood preparedness, flood proofing, and enhancing the traditional adaptations which Bangladeshis have developed over generations of living on the delta.

Flood management, as opposed to flood control, seeks to minimize flood damages without massive structural intervention in the river system. In the United States and other developed countries, flood damages have grown

dramatically despite huge investments in dams, embankments, and other structural flood control measures. From $1 billion per year in 1958, flood losses are expected to exceed $6 billion per year in the United States by the year 2000 (Goddard 1976). As a result, flood management, in the form of zoning, insurance, flood proofing and warning systems, is now seen as more effective in protecting lives and cost-effective in reducing flood damages (Costa 1978).

The people of Bangladesh have developed many ingenious ways of living through the floods and taking advantage of the beneficial qualities. Resources should be focused on helping them adapt more effectively through a combination of traditional and modern flood management techniques. This view is shared by many of the experts including the authors of the USAID study who *"strongly recommended that international assistance be provided to support actions that will help people `live with floods'."*

Residents of flood-prone areas have traditionally built platforms or anchored rafts on which to ride out the high water. Those who can afford to, build brick houses with flat roofs for flood refuge. When extreme floods occur, such as the 1987 and 1988 floods, millions of rural people are forced to flee their homes for higher ground, using road embankments, bridge abutments and flood control embankments. Dedicated refuges should be built in every community where people could gather during high water. These should be equipped to provide tents, clean water, food and medicine.

There is a need for a flood forecasting and warning system which would provide people with adequate time to harvest threatened crops and move themselves and livestock to refuge areas. Disaster relief agencies would have time to move food, medicine and other supplies to local refuges and distribution centres. A flood warning system exists but cannot meet the need due to delays in receiving hydrologic data from upstream and the lack of an effective means for communicating the flood forecast to threatened communities. Better computer modelling would allow more accurate and locally specific forecasts. Developing a computer model is one component of the FAP, however, that model will be of the FAP system and given the experimental nature of the embankment scheme and the numerous unanticipated changes in the river system, such a model would remain experimental for years to come.

Bangladeshi farmers have developed intricate cropping patterns which reflect the expected degree and timing of flooding, taking advantage of the

flood tolerant broadcast *aman* rice variety. Growing as fast as 15 cm. in a 24 hour period, this floating variety can keep pace with rising flood waters and survive in water of 7 metres or more (Adnan 1991). Much of the damage to floating rice occurs when boats tear through the flooded fields or water hyacinths invade so farmers build bamboo fences to protect the rice. Research should be directed toward improving yields of this flood tolerant variety and other wet season crops. Progress has been reported in developing improved varieties of deep water *aman* and new varieties of HYV *aman* suitable for transplanting after recession of flood water (World Bank 1990a).Improvements in local drainage are needed to reduce wet season crop losses. Much of the waterlogging results from poorly designed road and railway embankments, which were often laid out without reference to natural drainage pathways. Retrofitting this grid of transportation embankments should go along with promoting boat travel during the wet season to reduce the need for road embankments. Some limited improvement of local drainage could be achieved by dredging the openings of abandoned distributary channels as well.

A program of flood proofing of urban areas is needed, moving sensitive equipment such as electric motors to higher floors and constructing flood proof masonry foundations for example. Flood walls protecting individual buildings or industrial centres would stand a better chance of being properly maintained than the existing urban flood walls which are broken repeatedly to allow vehicle access. Ring embankments around urban areas might be successful if careful maintenance could be assured along with adequate pump systems for drainage. Flood zoning should be introduced for all new development to prohibit siting of important facilities on low lying land.

Management of Coastal Floods

Many of the same flood management measures can be used to reduce the loss of life from cyclone driven coastal floods. High ground storm refuges are desperately needed in the coastal region. When the last cyclone struck in April 1991, only 10 per cent of the 2,500 refuges planned for this region had actually been built (New Scientist 1991). One third of the survivors of the 1970 cyclone lived by climbing trees to escape the storm surge (Rashid and Paul 1987). Many of these trees were tall coconut and palms planted near houses for the purpose of flood refuge they offered. Boats also offer

safety and a means of evacuation from the many coastal islands inhabited by hundreds of thousands of landless Bangladeshis.

In the United States, the approach of similar hurricane storms is forecast days and even weeks in advance, allowing adequate time for preparedness and evacuation. The same type of system in Bangladesh could prevent the huge loss of life suffered regularly by coastal communities.

Upstream Storage Dams: No Solution

Since Bangladesh occupies only 8 per cent of the drainage basin of the combined Ganges-Brahmaputra-Meghna Rivers system, it is not surprising that many Bangladeshis have looked upstream for solutions to the flooding problem. One suggestion has been to build a series of storage dams in the upper reaches of the watershed, across the steep valleys of the Himalayas in India and Nepal. However, even a cursory analysis shows that even the most ambitious dam building program would have negligible impact on flooding in the delta of Bangladesh.

The amount of water which would need to be stored is huge, on the order of 100 billion cubic metres of live storage, requiring dozens of large dams costing many billions of dollars each (Rogers *et al.* 1989). The first beneficiary of the flood storage capacity would be the Indian flood plain areas directly downstream where overbank flooding would be reduced, in itself no help to Bangladesh. Such a system of high dams would certainly be used for hydropower generation and irrigation supply. Both hydropower and irrigation require maintaining high water levels in the reservoirs, reducing the potential storage available for flood control considerably. These other uses would undoubtedly be more to the Indian officials operating the facilities, leaving flood control for Bangladesh at best third on the list of priorities.

Furthermore, sedimentation would gradually rob the reservoirs of their storage capacity, necessitating construction of new dams until all feasible sites were exhausted. At least 50 years would be required to construct the storage capacity necessary to make a noticeable reduction of flood levels in Bangladesh. After that period of time, the first dams would already be silted up.

In addition to the great financial cost of building dozens of high dams in the Himalayas, there are serious environmental and social costs. The best

agricultural land would be flooded, tens of thousands of people forced to move, fisheries destroyed and wildlife habitats affected. In the Himalayas, a zone of intense tectonic activity, the risk of a dam failure due to earthquakes is very high. Such a collapse would cause a devastating flood more damaging than the floods the dams were built to prevent.

It is questionable whether significant reductions in flood levels in Bangladesh are physically possible through storage dams in the Himalayas. Much of the water making up the floods falls as rain onto Bangladesh itself, or the upstream plains of India, well below the potential dam sites. For example, 90 per cent of the rainfall which caused the 1988 flood occurred in the downstream plains of India and Bangladesh (Ahmad 1989).

The height to which rivers rise during high volume flows is not necessarily reduced when flows are reduced. Large changes in discharge, or the rate of water flowing past a given point, can result in virtually no change in the state, or elevation of the river water surface. Hydraulic engineers call this a "non-linear stage discharge relationship". Halving the flow in this segment of the Padma River from 90,000 cubic metres per second (cumecs) to 45,000 cumecs results in no change in water elevation. What does change is the velocity of the river current, as a result of complex changes in the shape and size of riverbed dunes which affect the friction applied to the moving water.

Recent research suggests that with construction costs of $60 billion, dams in the Himalayas could have stored at most 22 billion cubic metres during the 1988 flood. This would have reduced the peak flood elevations, which reached inundation depths of 6 metres or more in some areas, by only 0.2 to 0.4 metres, not enough to affect flood damages significantly (Simons and Colombi, as cited in Rogers *et al.* 1989).

FAP: A Failure in Planning

The emphasis on structural flood control in the FAP reflects a basic planning failure in which the mistakes of the past are to be repeated while valuable opportunities and resources are wasted. Past studies which examined Bangladesh's problems in far greater detail and done without the political impetus which followed the 1988 flood have been virtually ignored in the formation of the FAP. The World Bank completed an exhaustive 9 volume study of Bangladesh in 1972 called the Land and Water Resources Study which advised against any attempt to embank the dynamic rivers of

the delta. Instead it called for dry season minor irrigation expansion, prioritization of protection from coastal flooding and flood management measures to deal with river floods. The Bangladeshi government came to similar conclusions in developing the comprehensive National Water Plan of 1986 (World Bank 1990b).

The lack of public participation in formulating the FAP is also responsible for the ill advised emphasis on structural flood control. According to a 1989 UNDP study, the failures of past projects were due in part from *"the technocratic way in which flood control drainage and irrigation projects were designed and executed; people were not involved at any stage in the project cycle"* (World Bank 1990b). Despite the fact that the FAP document calls for *"closer involvement of the beneficiaries and local authorities in the planning, design and management of projects,"* public participation has been minimal to date (World Bank, 1990a). Only FAP component 22, covering compartment pilot projects has any explicit public participation. Not only has the Bangladesh public been excluded from FAP planning, *"the FAP is marred by instances of harsh repression of the critical dissent voiced by concerned Bangladeshi professionals"* according to Dr. Shapan Adnan of Research and Advisory Services a Bangladeshi non-governmental organization (Adnan 1991).

In spirit, the FAP calls for a staged approach that will learn from the results of experimental pilot projects and planning studies of environmental impacts and socioeconomic constraints. Yet while the studies go forward, work will also commence on the embankments which form the backbone of the structural approach. Not only does the FAP fail to learn from the 25 year record of flood control in Bangladesh, but *"there is a real danger that the results of the studies, especially where significant adverse environmental or social impacts are identified, will be unable to influence or change project implementation,"* according to a study by the International Institute for Environmental and Development (Dalal-Clayton 1989). Major work is scheduled to begin on embankments along the right and left banks of the Brahmaputra, the Ganges right bank and Meghna left bank during 1992, yet the pilot river-training project will not be completed until 1995 (World Bank 1990a). Even then it may be years or decades before the experimental groynes and dykes are tested by an extreme flood event. The results of these tests may be essential to guide the decision on how large a setback is required to protect embankments from erosion.

Moving forward with construction of the first phase of the embankment system undermines the other FAP components which are examining non-structural flood management measures. Embankments, like dams, give the false impression that flood risk has been eliminated, removing the incentive to develop flood warning and preparedness programs. The institutional bias towards large scale, centrally controlled structural investments will favour embankments unless there is an explicit commitment to non-structural solutions.

Structural plans can develop a momentum which is very difficult to stop. According to the National Water Plan, momentum acquired by questionable structural projects meant that *"there was little scope to reassess the overall investment program without abandoning a large number of ongoing investment projects"* (World Bank 1990b). Many unsuccessful development projects have proceeded to completion on the basis of monies already spent, even when the overall project had been discredited early on. However, there is still time to reconsider the FAP and redirect thinly stretched development resources toward more cost effective and reliable alternatives.

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CHAPTER SIXTEEN

FLOOD ACTION PLAN REPORT ACHIEVEMENTS AND OUTLOOK*

William T. Smith

Background

Purpose and Scope of Report

The Flood Action Plan (FAP) is the first stage in the development of a long-term plan for flood control, drainage and river management in Bangladesh. Over the past two years, the FAP has provided a framework for a wide range of investigations into the technical, social and environmental issues to be faced in formulating such a plan. The FAP's systematic, coordinated approach supported by numerous bilateral donors, the UNDP, the Asian Development Bank and the World Bank has contributed to a deeper understanding of the problems and potentials of water control in Bangladesh. This report provides an account of the work carried out over the past two years, presents proposals for further FAP activities for the next three years and looks ahead to the longer-term prospects for flood control and drainage.

This section of the report describes the origins of the FAP and the arrangements that are in place for its management and coordination. Next, it provides a brief account of the physical and socio-economic setting for the benefit of readers unfamiliar with Bangladesh. Then it presents a summary of progress to date on the FAP's twenty-six activities. Thereafter is an

*This chapter has been reproduce from a Draft for Discussion jointly prepared by the Government of Bangladesh and the World Bank in March 1992.

overview of a wide range of issues which bear on flood control, drainage and river management and the last section draws on material in preceding chapters to indicate future directions for the Flood Action Plan.

Origins of the Flood Action Plan

In 1987 and 1988, Bangladesh experienced two of the most severe floods on record. There was widespread damage to crops, roads, railroads, towns and villages, and more than three thousand people lost their lives. These events stimulated the production of several studies to explore ways of mitigating the effect of floods. A UNDP/Government of Bangladesh team carried out a Flood Policy study. A team of experts from Bangladesh and France prepared a "Pre-Feasibility Study of Flood Control". USAID sponsored an "Eastern Waters Study". Also, a team of experts from Japan reviewed various options for flood control. In addition to these initiatives, many countries expressed interest in helping Bangladesh in the longer term beyond the immediate provision of emergency supplies of food, clothing, fuel etc. In June 1989, the World Bank agreed to a request from the Government to help co-ordinate these international efforts. This action was endorsed in the July 16, 1989 communique of the G-7 Summit in Paris which called on the international community to support the Government in finding solutions to the flood problem.

As a first step in meeting its co-ordinating responsibility, the Bank convened a meeting in Washington on July 11-13, 1989, attended by the leading experts from each of the main studies and by a delegation from the Government of Bangladesh. It was agreed to concentrate on an Action Plan for the next five years as the first step in formulating a longer-term flood control program. Arrangements to prepare such an Action Plan, put in place during the July meeting, provided for the Bank to be assisted by many of the key experts who had been involved in the UNDP, USAID, French and Japanese studies. A draft report was completed in August and finalized in consultation with Bangladesh officials during meetings in Dhaka and Washington in October 1989. The report proposed 26 components of which 11 are Main Components consisting of regional and project-oriented activities, and 15 are Supporting Studies. The Action Plan Report was presented to a meeting of donors held at Lancaster House, London on December 11, 1989. The donors expressed widespread agreement with the

basic approach outlined in the Report. Within a short time after the meeting, all of the 26 components of the Plan had received donor support, and UNDP had agreed to provide funding for FAP co-ordination and technical review.

The Government of Bangladesh established a National Flood Council and an Implementation Committee for the Action Plan in September 1989. The Council, headed by the President, periodically reviews progress on the Action Plan and formulates policies needed to ensure timely implementation. The Implementation Committee, headed by the Minister of Irrigation, Water Development and Flood Control (MIWDFC) and composed of the Secretary Irrigation, Secretary Finance and the Secretary Economic Relations Division ensures co-ordination between ministries and reviews and approves actions on major issues relating to the Action Plan. The Secretary Irrigation, as the highest level government officer with personal responsibility for the Action Plan, draws on the services of a Technical Committee which he chairs. The membership of the Technical Committee includes representatives from all relevant ministries and government agencies, the FPCO and POE (described below), and the World Bank's Resident Co-ordinator. In addition, a full-time government body, the Flood Plan Co-ordination Organization (FPCO), was set up in early 1990 to provide day to day co-ordination of the Action Plan. The FPCO is supported by UNDP Project BGD/90/004 and is headed by a Chief Engineer. The FPCO is, in turn, supported on technical and co-ordination matters by a Panel of Experts (POE) composed of local and international experts. The POE is financed in part, by several of the donors and in part, by UNDP Project BGD/89/046.

Management and Co-ordination

In early 1990, work began on preparing the Terms of Reference (TOR) for work on the various components of the Plan (see Table 1). In a few cases, the drafting of TORs and the selection of consultants had been initiated prior to the formulation of the Action Plan. But most components of the Plan were entirely new initiatives and, for some of them, it was decided that a preliminary reconnaissance phase was needed to form a sound basis for drafting a comprehensive TOR. Examples where an extensive first-phase reconnaissance was undertaken, were two of the regional studies (North Central and Northwest), fisheries, river surveys, and pilot projects for bank

Table 1

Action Plan Components and Supporting Studies

FAP NO.	Activity	Donors	Est. Cost (equiv. $ mill.)
MAIN COMPONENT			
1.	Brahmaputra Right Bank Strengthening	IDA	3.4
2.	Northwest Regional Study	The UK, Japan	4.6
3.	North Central Regional Study	EC, France	2.5
3.A	Jamalpur Priority Project	France, EC	1.7
4.	Southwest Regional Study	UNDP, ADB	3.8
5.	Southeast Regional Study	UNDP, IDA	2.2
6.	Northeast Regional Study	Canada	14.6
7.	Cyclone Protection Project	EC	1.6
8.	Dhaka Town Protection		
8.A	Master Plan	Japan	3.0
8.B	Priority Projects	ADB/Finland	0.6
9.	Secondary Towns Protection		
9.A	District Towns Protection	ADB	0.6
9.B	Meghna River Bank Protection Study	IDA	2.0
10.	Flood Forecasting and Warning	UNDP, Japan, ADP	5.7
11.	Flood Preparedness	UNDP	NA
SUPPORTING STUDIES			
12.	FCD/I Agricultural Review	The UK, Japan	1.6
13.	0 & M Study	The UK, Japan	0.6
14.	Flood Response Study	USA	0.7
15.	Land Acquisition and Resettlement Study	Sweden	0.4
16.	Environmental Study	USA	1.2
17.	Fisheries Study and Pilot Project	The UK	3.4
18.	Surveys and Mapping	Finland, France Switzerland	6.0
19.	Geographic Information System	USA	1.7
20.	Compartmentalization Pilot Project	The Netherlands, Germany	11.4
21.	River Training Pilot	Germany,	40.0
22.	Project	France	
23.	Flood Proofing Pilot Project	USA	0.2
24.	River Surveys Program	EC	14.0
25.	Flood Modelling and Management Project	Denmark, France, , The UK The Netherlands	2.7
26.	Institutional development Study	UNDP	0.9

protection/river training and compartmentalization. For most of the supporting studies, it was found appropriate to proceed directly to writing the TOR. For a typical Action Plan activity, the first draft of a TOR was written by experts fielded by the donors in consultation with government inter-agency working groups, the POE, the FPCO and the Bank. Once the draft was agreed, the FPCO produced the TOR in a standard format suitable for use by the donors in inviting proposals from consultants. At the same time, FPCO prepared a Technical Assistance Project Proforma (TAPP), an internal document required for all technical assistance activities in Bangladesh. As they were completed, the TOR and TAPPs were submitted to the Technical Committee for review and approval, and the procurement process began as soon as the TOR had been approved. The donors procured consulting services following their own procedures. In most cases, short lists were prepared, sometimes based on responses to pre-qualification enquiries.

Thus, the main study phase of the FAP was preceded by intensive and thorough preparation to identify the scope and purpose of the various activities. Each TOR provides for periodic review by the FPCO, other Government agencies where appropriate, the POE, the Bank, and the donors. The consultants are required to keep in touch with the Supporting Studies and to co-ordinate with them where appropriate. Informal exchanges of views between the various consulting teams has been encouraged and facilitated by the FPCO, the POE and the Bank's Resident Co-ordinator. Workshops and seminars have been arranged on several of the Supporting Studies. Experts in specialized fields have been retained to work periodically as members of the POE and a number of donors have funded the services of such experts. In view of the importance of hydro-dynamic modelling, an expert panel has been established under FAP 25 to provide technical advice and oversight; this is known as the Co-ordination and Advisory Team or CAT.

The regional studies have emerged as key elements of the FAP. These are major multi-disciplinary investigations of water control problems aimed at finding solutions that can be shown to be technically, economically, socially and environmentally sound. The Supporting Studies, especially those bearing on social and environmental issues, have been designed to collect and analyze basic data and past experience in land and water resource development.

During the preparation of the TOR, it became apparent that the work of the consultants and the reviewers would be simplified if a common basis were established for many of the elements which go into project analysis and assessment. Therefore, the "Guidelines for Project Assessment", prepared are now in use by the study teams. A procedure for reviewing consultants' reports has recently been established and has been used so far to review inception and interim reports. A Review Committee then meets with the consultants to resolve any issues and points of difference, and the agreements reached are recorded and reflected in the consultants' final report.

The Physical and Socio-Economic Setting

Overview

Bangladesh, with an area of 145,000 km^2 and a population of about 110 million, lies in the floodplains of three great rivers, the Jamuna, the Ganges and the Meghna. Each year, from June to September, the flow of warm moist air from the Bay of Bengal, produces heavy rainfall over Bangladesh and the drainage basins of these rivers. Average annual rainfall ranges from a low of 1,200 mm in the west to almost 6,000 mm in the east where the highest rainfall areas of the world are found just beyond the border with India. In most years over 60% of the country's cultivable area of 95,000 km^2 is flooded to some degree through overflow from rivers and accumulation of direct rainfall.

The severe floods of 1987 and 1988 differed in their nature and origin. The 1987 flood was produced by heavy and prolonged rainfall from July to September over northwest Bangladesh and West Bengal. The 1988 flood, in contrast, was caused by intense rainfall over north and northeast Bangladesh, and the lower parts of the Jamuna and the Ganges drainage basins in India.

Despite its exposure to floods and cyclones, Bangladesh is intensively cultivated and, although it is one of the world's most densely populated countries, its production of foodgrains comes close to self-sufficiency. Outside of large areas of the Northeast, where only a single crop is possible, the cropping intensities range from 125-150% in the west to 180-200% in the east. Steady gains in agricultural output in the 1980s have come largely from the exploitation of groundwater for dry-season cropping; most of this groundwater is found at shallow depths and is recharged each year by the

heavy rainfall. Low-lift pumping from perennial water bodies has also become more widespread in recent years as a source of dry-season irrigation.

Unfortunately, the gains in production have been matched by rapid growth in population. The farm size has dropped from 1.5 ha to 0.9 ha over the past 20 years and the proportion of households that are landless has risen from 35% to 45%. Underemployment in rural areas at present is about 30-40%, and in recent years there has been a secular decline in wage rates and landless household incomes.

Rice is the main crop grown in Bangladesh, accounting for about 78% of the cropped area. The other main crops are jute (5% of the area) and wheat (4%). In addition, numerous minor crops are grown, mainly in the dry season, such as other cereal and fibre crops, fruit, vegetables, spices, pulses and oilseeds. There are three rice growing seasons in a year—aus (harvested early in the monsoon season), aman (grown in the monsoon but harvested after) and boro (grown in the dry season). The Bangladeshi farmers are skilled at suiting their rice cultivation practices to the water regime. The boro crop is always transplanted. Both traditional and high yielding rice varieties (HYV) are used where the crop is transplanted—the choice usually depends on reliable water control. Flood protection and drainage leads to higher production through a switch from B.aman to T.aman and wider use of HYV.

Fishing is a significant source of income for rural households and provides some 70% of animal protein intake. Inland fisheries account for 70% of the catch divided between capture fishery in open waters (50%) and culture fisheries in privately owned ponds and coastal shrimp farms (20%).

The Regions

For the purposes of the FAP, the country has been divided into five regions. The following brief overview sets the background for discussing progress on the FAP activities and issues of flood control, drainage, and river management in the subsegment sections.

The North West Region bounded by the Jamuna on the east and the Ganges to the south, is drained by the Teesta, the Atrai and other perennial rivers rising in India. The region comprises a large uplifted block, the Barind Tract, in the centre-west, bordered by the Teesta and related floodplains in the north, the Karatoa-Bangali floodplain in the east and the Ganges

floodplain in the south. Annual rainfall ranges from 1,250 mm in the west to more than 2,200 mm in the north and northeast. Seasonal flooding is mainly intermittent or shallow, but a substantial area in the southeast is deeply flooded when high stages of the Jamuna impede outflow from the Hurasagar channel through which some 80% of the region's drainage flows. Substantial areas are double-cropped, party with the help of tubewell irrigation which has spread rapidly in the past decade, but drier western areas and low-lying areas in the southeast are mainly single-cropped. The Brahmaputra Right Embankment (BRE), dating back to the 1960s, extends 217 kms along the Jamuna, and there is an embankment along the entire length of the left bank of the Ganges. Other existing works aimed at water control include numerous polders along the lower Atrai and embankments along other internal rivers. Bank erosion is a significant problem in places along the Jamuna, leading to loss of land which has forced the retirement of the BRE over more than half its length and requiring costly investments in attempts to protect Sirajganj town.

The North Central Region is bounded by the Jamuna river in the west, the Old Brahmaputra channel in the north, the Lakhya and the Meghna rivers in the east, and the Padma in the southwest. It is crossed by the Dhaleswari, the major distributary of the Jamuna. The region comprises the Jamuna floodplain and parts of the Old Brahmaputra, Ganges and Old Meghna floodplains, together with a large uplifted block, the Madhupur Tract, in the centre-north. Annual rainfall ranges from 1,600 mm in the west to 2,200 mm in the northeast. Seasonal flooding is mainly shallow in the north becoming deeper in the centre and south where drainage is impeded when the lower Jamuna, the Padma and the Meghna rivers are at high flood stages. Many flood plain areas are double or triple cropped, and there has been a rapid expansion of tubewell irrigation in recent years. The region has about 200 kms of existing embankments to provide protection against overbank flooding, of which 50 kms extend along the left bank of the Jamuna. Various forms of flood control and drainage project serve about 73,000 ha. The greater Dhaka area was badly hit by the 1988 flood and works to protect Dhaka city were started immediately after the floods.

The South West Region is bounded by the Indian border in the west, the Ganges-Padma in the north, the lower Meghna in the east and the Bay of Bengal in the south. The region covers 4.0 m.ha of which 2.5 M.ha is cultivated, 0.4 M.ha is coastal mangrove (including the Sundarbans) and

0.7 M.ha is taken up by rivers and beels. The region mainly comprises the Ganges river and tidal floodplains, with the low-lying Gopalganj-Khulna beels in the centre. Annual rainfall ranges from 1,500 mm in the west to 3,000 mm in the southeast. Seasonal flooding is mainly shallow in the west and on the tidal floodplain in the south, but is deep in the centre and east. There is double and triple cropping in the north and east, but south-western parts of the tidal floodplain and low-lying beel areas are mainly single cropped. In recent years, brackish water shrimp cultivation has spread rapidly, and is now a substantial source of foreign exchange earnings. Southern and western parts of the tidal floodplain have been enclosed by the Coastal Embankment Project since the 1960s, and embankments have been built along most parts of the Ganges and the Padma right banks. The Ganges-Kobadak Project provides irrigation to *kharif* crops on 52,000 ha in the northwest, and tubewells and low-lift pumps provide dry-season irrigation to substantial areas in other parts of the region.

The South East Region occupies the area between the Indian border in the east, the southern part of the Sylhet basin in the north, the middle and lower Meghna channels the west and the Bay of Bengal in the south. The Meghna estuarine and river floodplains occupy most of the region, with a small strip of piedmont plains adjoining hills along the eastern border. Annual rainfall ranges from 2,000 mm to 3,000 mm. Local relief is much less in this region than in the other regions, and substantial areas in the north and centre are deeply flooded; flooding is shallow in the southeast and near the coast. Flooding is mainly caused by ponded rainwater, but the eastern parts are affected by flash floods from the eastern hills. The southeast is the most intensively cultivated of the regions. Of the cultivated area of 776,000 ha, some 30% is irrigated by tubewells and low-lift pumps. Existing flood control and drainage projects in the region include Chandpur (56,000 ha), Meghna-Dhonagoda (17,000 ha), and Gumti Phase I (37,000 ha). Bank erosion is serious along parts of the lower Meghna, posing threats to Chandpur town and the Chandpur Irrigation Project.

The North East Region is bounded in the north and east mainly by hills bordering India, in the west by the Old Brahmaputra and Lakhya rivers,and in the south by the Meghna river and the northern boundary of the Southeast region. This is the wettest region of the country, with annual rainfall ranging from 2,200 mm in the west to over 6,000 mm in the northeast; the region also receives run-off from hills across the northern border where

rainfall totals exceed 10,000 mm. There are three main physiographic units: the Old Brahmaputra floodplain in the west and south; the Surma-Kusiyara floodplain in the east; and the low-lying Sylhet Basin in the centre-north. Seasonal flooding is mainly shallow in the east and west, with flash flooding along the foot of the hills. Central and southern areas are subject to deep flooding, and depression centres (*haors*) within the Sylhet Basin and along the foot of the northern hills remain wet through the dry season. A single crop of boro paddy is grown in the *haor* areas and in depressions on the Old Brahmaputra floodplain. Higher land in other areas is mainly double cropped. Tubewell irrigation is extensive in parts of the Old Brahmaputra floodplain, but not elsewhere. Some eastern rivers have embankments designed to contain monsoon floods, but problems arise from breaching of embankments and siltation of river-beds.

Progress to Date

The elements of the Flood Action Plan are summarized in Table titled 'Action Plan Components and the Supporting Studies' which shows the donors and the estimated cost of each activity. Broadly, the activities are divided into 11 main components and 15 supporting studies or pilot projects. The remainder of this chapter is devoted to briefly summarizing the status of each activity. The way in which the studies have been managed is described in the beginning of this chapter The review of issues draws on some of the findings of these studies.

Main Components

FAP 1—of the Brahmaputra River Training Study

The purpose of the study is to formulate a long-term plan for the protection of the Brahmaputra Right Embankment (BRE) and to design measures for protection at critical sections along the right bank for immediate implementation. The study has found indications that the Brahmaputra/Jamuna between the Indian border and the Ganges has increased its width over the past thirty years especially between Fulchhari and Sirajganj, and that north of the Ganges confluence, the right bank is moving to the west at some 100 meters per year. Therefore, the approach proposed by the study is to concentrate on securing several critical points and, in the longer-term, to secure intermediate points. Priority locations, including the town of Sirajganj have been

identified and a feasibility study for a first phase project is nearing completion. In places, the protection of the right embankment would be extremely costly, even if it were technically feasible, and retirement to a new location is the logical solution. However, retirement presents social problems since many farmers lose their land and homes.

FAP 2—Northwest Regional Study

The objectives are to assess the flood control and drainage options in the region, and to carry out feasibility studies for priority projects. A Preliminary Review in June 1990, which examined the present situation, reviewed possible options and drafted the TOR for the main study. A bridging study from July to December 1990 made a start on hydrological studies and mathematical modelling while procurement of consultants was proceeding. The main study started in January 1991, the Inception Report was completed three months later, and the Interim Report was submitted in October 1991. The study has confirmed that the main problem areas are along the Jamuna and the Lower Teesta right banks and in the Lower Atrai basin. Various options and scenarios were considered. The option of constructing major drains to intercept the flows of internal rivers and divert them to the Jamuna or the Ganges to relieve Lower Atrai flooding does not appear economically attractive, but smaller diversions are being studied. Improved flood protection and drainage in specific areas have potential benefits from intensification of agriculture and reduction in flood damage. Special attention is being given to potential conflicts between capture fishing and agriculture and measures to enhance capture fisheries are being explored. The Interim Report has identified the 100,000 ha Gaibandha Improvement Project in the angle between the Teesta and the Jamuna as having priority for flood protection and drainage; it appears to have a good economic return and positive social and environmental aspects.

FAP 3—North Central Regional Study

The study is to examine alternative water control strategies and recommend a regional plan. It will also identify priority projects and subject them to prefeasibility studies. The study began in March 1990 with a detailed reconnaissance which reviewed the present situation and explored and finalized the main study TOR. This was followed in July by a six-month bridging input

from a hydrologist-modeller who assisted in the development of a pilot hydraulic model and supervised channel surveys. The main study started in January 1991 and the draft Interim Report was submitted in November 1991. The main flood-prone areas are in the south and west which are subject to inflows from the Jamuna and its distributaries and, in some years, through overbank flow. The flood problem is compounded by poor natural drainage. The region has been divided into thirteen planning units and development options are being assessed for each unit and for the region as a whole. There is a potential for improved drainage in the northern part of the region where gravity drainage is possible, but in the southern part, drainage is impeded by high levels in the Padma and the Meghna. However, there is scope for improvements in water control through reducing inflow from the Jamuna and its distributaries. Socioeconomic studies in the region have shown that normal flooding is generally perceived by the public as beneficial. This underscores the need to explore the concept of controlled flooding. This could be achieved through application of the compartmentalization concept now being developed as a pilot project (see FAP 20).

FAP 3.1—Jamalpur Priority Project

This project was identified as a potential priority project in the early stages of FAP 3. It is located in the most northerly part of the North Central Region in the angle between the Jamuna and the Old Brahmaputra. The project area of 90,000 ha has the possibility to benefit from reduction in overbank flooding from the Jamuna if protected by low embankments set back a safe distance from the river. Gravity drainage would also be feasible for much of the area. An important part of the feasibility study, which started in August 1991, will be to examine the interaction of the project with adjacent areas, including the charlands in the Jamuna. This will be the first study of a specific flood control and drainage (FCD) project in the FAP and will involve a full multi-disciplinary team giving particular attention to social and environmental aspects.

FAP 4—Southwest Regional Study

The study aims to produce a long-term plan for land and water resources development; identification of priorities for development and feasibility

studies of selected priority projects. The consultants were mobilized in October 1991, and the study is now underway. This region presents a range of problems: dry season water shortages in the west, flooding in the east, salinity intrusion and storm surges in the south, and floods and drainage congestion in the polders of the southwest.

FAP 5—Southeast Regional Study

This study was initiated prior to the FAP and hence is concerned with year-round water control. Its objective is to prepare a regional plan to address the problems of floods, drought, drainage congestion and storm surges. The study will compare options for the use of surface and groundwater (including the transfer of water from the Meghna to the Muhuri); identify development priorities; and conduct feasibility studies for priority projects. For the study, the region was divided into a number of units, based on physiographic conditions. Three units appear to be good prospects for further evaluation as priority projects and Noakhali North (140,000 ha) appears to be the most attractive. This would improve drainage of the Begumganj depression, an area suffering from drainage congestion through the continuing accretion of new land along the Noakhali coast and the silting of the natural drainage channels. The project would have little effect on capture fisheries and it would offer new opportunities for culture fisheries.

FAP 6—Northeast Regional Water Management Study

The study's objective is to prepare a regional plan for land and water development and identify specific project priorities. A reconnaissance of the haor areas was carried out in 1989/90 and the project started in August 1991. A comprehensive data base is being set up and thematic studies in relevant disciplines have started. The Asian Wetlands Bureau started field studies in ornithology and wetland ecology in January 1992. Arrangements have been made to secure the help of NGOs in enlisting public participation in the planning process and in developing ideas for local involvement in project operation.

FAP 7—Cyclone Protection Project

The project comprises two main elements: strengthening and improving coastal embankments, and improvement of feeder roads within the protected

areas. While the project was being prepared, the main project area was hit on 29/30th of April 1991 by one of the most severe cyclones on record. Therefore, priority was given to reconstruction and this led to a project to repair 200 kms of damaged embankments and ten of the most severely damaged polders. Detailed designs and bid documents have been completed and issued to bidders for this priority project. A second and larger project is under preparation. A new design to be employed for the embankments will substitute compacted clay for the usual slope protection of concrete or brick and, where possible, the foreshore will be planted with a protective belt of trees. Design of the roads is in progress and, in order to ensure that the roads will be passable in emergencies, they will be provided with an all-weather surfacing. These projects will include efforts to secure the involvement of the beneficiaries in the maintenance of roads and embankments.

FAP 8A—Greater Dhaka Flood Protection Project

This study aims to formulate a master plan for comprehensive flood control and storm water drainage for the Greater Dhaka Area covering some 85,000 ha. and to carry out a feasibility study on flood control and storm drainage projects in priority areas. The draft Master Plan has been submitted and approved, and the final report is being prepared. Feasibility studies for three priority projects are in progress.

FAP 8B—Dhaka Integrated Flood Protection

The project area is the Dhaka Metropolitan Area which covers 26,000 ha. The feasibility study was completed in September 1991. It concluded that first priority should be accorded to the area to the west of the existing spine road, running from the Friendship Bridge to Tongi Railway Bridge. Major components of the project are: repair and strengthening of the existing western flood embankment; closing gaps in the flood wall along the Buriganga River; improvement of the drainage network, including sluices and a pumping station; and a pilot component involving sanitation, slum improvement and solid waste collection and disposal. Detailed designs and bid documents are being prepared. FAP 9A—Secondary Towns Protection

An Interim Report has identified a number of secondary towns with priority for bank protection and has drafted plans for flood control, drainage improvement, solid waste management and slum improvement. The six

towns are Khulna, Kurigram, Panchagarh, Moulvibazar, Habiganj and Dinajpur. The next step is to screen the proposals and prepare feasibility studies for the selected towns.

FAP 9B—Meghna Left Bank Protection

The objectives of the study are to recommend measures to combat river bank erosion at critical points on the Meghna and the Dhaleswari. The recommendations and proposed designs are based on an extensive program of field investigations and modelling. Locations identified where protection is urgently required are: Bhairab Bazaar Township and Railway Bridge, Munshiganj (Dhaleswari) and Chandpur. A solution to the long-term bank erosion problem at Chandpur presents a major challenge in view of the depth of scour and the high flow velocities. Detailed designs and bid documents are being prepared. An important aspect of this project will be to monitor the performance of the protection works and the costs of annual maintenance.

FAP 10—Flood Forecasting and Early Warning

The objective of the project is to upgrade the capacity of the Flood Forecasting and Warning Centre of the Bangladesh Water Development Board (BWDB). The project will extend the shortwave radio network, overhaul and calibrate the weather radar, design and install weather satellite receivers, upgrade computer systems, develop data exchange with the Bangladesh Meteorological Department (BMD), and develop flood-forecasting models. The weather satellite equipment has been installed and is in operation and the installation of the computer local area network is well advanced. The pilot telemetry system will be operational before the 1993 monsoon season, and the radar network should be operational by mid-1992.

FAP 11—Disaster Preparedness

This project has had to wait upon a decision by the Government on the responsible ministry. The Ministry of Relief and Rehabilitation has now been given the task of coordinating relief efforts. The first stage of a disaster preparedness study has been agreed with the Ministry of Relief, UNDP and FPCO. The procurement of consultants is complete and the project is expected to start in February 1992. The study will recommend ways to

assist the Ministry of Relief to fulfil its role as a coordinator of relief, repair and rehabilitation. It will help establish a Disaster Coordination and Monitoring Unit which will enable the Ministry to carry out its role as the focal point of all disaster-related activities. Also, preparations will be made for a long-term program of disaster preparedness. *Supporting Studies*

FAP 12—FCD/I Agriculture Review

A representative sample of FCD and FCD/I projects in different parts of the country have been reviewed to draw lessons and recommendations for use in FAP project planning, design and implementation. Seventeen completed projects were evaluated by multi-disciplinary teams (including engineers, natural resource specialists, social scientists and environmentalists) using both rapid rural appraisal (RRA) techniques and more intensive household surveys. The study, which took place from January 1991 to February 1992, revealed a wide range of project performance. About one half of the schemes have ERRs below 12%, while most of the remainder have ERRs over 30%. The best results are generally associated with technically simple projects of moderate size (under 10,000 ha), which seem to have the best chance of meeting local needs. In successful projects, improved water control has led to more productive wet-season cropping patterns. Drainage congestion due to high river levels presents problems in many projects. FCD/I projects often have an adverse impact on capture fisheries and fishing families. Landless households probably benefit less from FCD/I schemes than landowners, but crop intensification provides significant additional employment and normally raises wage rates. Many of the problems identified are due to weaknesses in project planning and failure to taken account of conflicting interests.

FAP 13—Operation and Maintenance Study

The aims of the study are: to identify the main constraints to effective O&M of water control projects; to provide guidelines for improving O&M; and to recommend ways to increase the participation of beneficiaries and the rural poor in O&M. The study took place from January to September 1991, and the Final Report was presented in January 1992. The study found that, in almost all projects, there was scope for improving O&M. In part, O&M difficulties arise from weaknesses in project planning and design. The study

concluded that although there is some involvement of beneficiaries it has not so far been too effective. But, this could in part be because of failures to consult the local people on the initial project concept. The study put forward several interesting project planning concepts. A second phase of this project is under consideration which will include field trials of new approaches to public participation in O&M.

FAP 14—Flood Response Study

The aims of this study are: to assess the response to floods of people living in flood-prone areas; to assess the likely impact of embankments and compartments on flood response; to provide guidelines on ways of enhancing effective flood response; and to develop criteria for use in the planning, design and operation of FAP projects. The study started in March 1991 and extensive field surveys were carried out during the 1991 flood season. Workshops in August 1991 and February 1992 reviewed the findings of the surveys, and supplementary follow-up surveys on special topics are underway. The project will be completed in August 1992. Studies to date indicate that many people give highest priority to supplies of water and fuel in emergencies. Few households want to be entirely free of flooding, but 75% want to be protected against severe floods.

FAP 15—Land Acquisition and Resettlement

The study, which lasted for twelve months and was completed in January 1992, identified the key problems and recommended a number of changes to existing laws and procedures to make the process of acquisition more efficient and to ensure that negative impacts are minimized. These include both changes in regulations and ways to ensure that households whose land is to be acquired participate in decisions on relocation, rehabilitation and resettlement. Most households interviewed regarded more prompt and adequate payment of compensation, and support for rehabilitation (such as job training), as being more important than resettlement.

FAP 16—Environmental Study

The objectives of this study are to: identify environmental issues associated with FAP plans and projects; prepare Environmental Impact Assessment

(EIA) guidelines and a User's Manual for data collection and analysis; undertake case studies and special studies as needed to develop and test assessment methodologies; develop recommendations for managing impacts, especially adverse ones; and assess EIA training needs. An Environmental Position Paper prepared in October 1991 summarized the environmental issues and main types of impacts that FAP teams can be expected to encounter in their project planning and environmental impact assessments. EIA guidelines were produced in draft form in July 1991 and were discussed at a workshop in Dhaka. The User's Manual would be completed in June 1992. Case studies of three FCD projects would be undertaken to test EIA methods and will be completed by mid 1992. Special studies of key environmental issues have been proposed. From an initial list of twenty projects, five are being considered for priority implementation. They include: nutritional values of fish; bio-diversity, disease vectors (mosquitoes and sand-flies); health and nutritional status in and outside of embankments; and a resource inventory of the charlands.

FAP 17—Fisheries Study and Pilot Project

This study has four main objectives: to establish the present status of floodplain fisheries in different regions; to predict the possible bio-physical, economic and social impacts of flood control interventions on capture fisheries; to assist in designing engineering and fisheries management measures to optimize fisheries benefits in FCD projects; and to carry out a pilot project to explore new approaches to aquaculture and re-stocking. A reconnaissance mission visited Bangladesh in April 1990 to identify suitable subjects for study and to prepare detailed TOR. The Project Memorandum was signed on 28 August 1991. A study team visited Bangladesh in August-September 1991 to prepare a detailed plan for operating the project, including the selection of sampling locations, identification of national staff and procurement of equipment. The first project staff members arrived in Dhaka in December to establish a logistical base, and full-scale operations would start early in 1992.

FAP 18—Topographic Mapping

This project aims to provide FAP studies and projects with topographic maps, thematic maps, aerial photography, satellite imagery, and vertical and

horizontal control points. SPOT imagery for 1989 at 1:50,000 scale for the whole FAP area was acquired and arrangement have been made to purchase SPOT imagery for 1990 for selected areas. A survey company (Finmap) has completed observations for 145 (out of 250 proposed) Global Positioning Stations and 1996 kms (out of 4,500 km) second order levelling points. Spot heights have been provided for almost the whole of FAP 3.1 Jamalpur Priority Project and Tangail Pilot Project (FAP 20). Finmap carried out aerial photography for 30,000 km^2 along the Jamuna in areas of interest for FAP projects and is now preparing 1:20,000 scale maps with 0.50m contours and 1:10,000 scale maps with 0.25 m contours for selected areas. Proposals are being considered for additional photography in January 1993 for parts of FAP regions not covered by the 1990-91 photography.

FAP 19—Geographic Information System

The project will provide a GIS facility to assist in planning and managing the geographic information for FAP, including promotion of standardized data protocols and data base formats, and assistance to FPCO in establishing a GIS network to serve the various FAP users. Training in GIS technology will be provided as workshops and on-the-job training. GIS technology, particularly PC-based systems, is being adopted by a number of organizations in Bangladesh and there is a growing demand for digital data bases and GIS training. The draft report "GIS Resources in Bangladesh" of June 1991 is a comprehensive documentation of existing systems in Bangladesh and capabilities of the proposed system. The GIS equipment was delivered in September 1991. Collaboration has been firmly established with other FAP components.

FAP 20—Compartmentalization Pilot Project

The objective of the project is to test the compartmentalization concept. In this concept, an area enclosed by an embankment would be provided with a comprehensive water control system designed and operated to satisfy the needs of the people within the project area. Many FCD projects, with similar objectives, have encountered problems which this project will try to solve. The first phase of planning and design, in close consultation with central and local government agencies and the public, is now in progress. The sites for two pilot projects have been selected; one on the left bank of

the Jamuna at Tangail and another one on the right bank north of Sirajganj and behind the right embankment. The consultants proposals, as they evolve, will be subject to a detailed review of all technical, social and environmental aspects. A decision to proceed with construction will be taken only after there is wide acceptance and understanding of the projects by the beneficiaries and assurance that no adverse impact will occur.

FAP 21/22—Bank Protection and AFPM Pilot Project

The objectives of the project are twofold: First to evolve new designs and construction materials to combat bank erosion by full scale trials works at selected locations on the Jamuna river and to monitor their behaviour. Second, to develop methods and pilot projects for active flood plain management (AFPM) of the main rivers in order to control bank erosion by channel diversion or stabilization. A contract was awarded to a consortium of consultants and contractors in October, 1991 and the team would be mobilized in the field by March 1992.

FAP 23—Flood Proofing Study and Pilot Projects

This study aims to identify ways to avoid or reduce the adverse impact of floods on the various social groups and their assets,, and on public and private infrastructure and facilities. It also provides for pilot projects to test flood proofing measures. A study has been completed of the flood response of local governments, industries and individuals in rural towns and surrounding areas. A number of potential flood proofing initiatives were identified by the study: information campaigns on flood hazards and measures to overcome them; the incorporation of flood proofing measures within FCD projects; and suggestions on how to promote flood proofing measures in the private sector. Representative flood-prone areas have been identified as possible sites for flood proofing pilot projects.

FAP 24—River Surveys

The objectives of the project are: to collect accurate hydrological and morphological data at a number of key stations on the main rivers; to undertake studies on the long-term behaviour of the river systems; to upgrade and strengthen the capability in Bangladesh in the fields of hydrological and

morphological data collection and river studies. The project is divided into two phases: the first one lasting one year, is designed to test methods and equipment for hydrological and morphological surveying on the Jamuna; the second phase will continue for three years, during which hydrological, morphological and hydrographic surveys will be carried out on the Brahmaputra/Jamuna, Ganges and Padma rivers and studies of the behaviour of these rivers will be taken up. At the end of Phase I, an international workshop on river processes will be held in Dhaka, which will give guidance to the river studies in the subsequent years. Proposals from several pre-qualified consortia were received in October 1991 and are being reviewed. It is expected that the consultants will be appointed shortly and that actual surveys will begin before the next monsoon season. Under a separate contract, the EC, the donor for the project, will appoint a project adviser, who, jointly with FPCO, will guide the project.

FAP 25—Flood Modelling and Management

The project which started in October 1990, has three components. The Flood Hydrology Study (FHS) is designed to establish the hydrological basis for engineering design criteria along the major rivers and to develop common modelling standards and techniques for the FAP studies. A Coordination Advisory Team (CAT) has been set up to assist and advise the Resident Modelling Coordinator, to ensure consistency and compatibility in modelling, and to coordinate development of models for FAP at the Surface Water Modelling Centre (SWMC). A Flood Management Model (FMM) is being developed for flood forecasting and the formulation of flood management strategies. The first two components are in progress and they draw on the considerable experience developed in recent years by the SWMC. Coordination between the SWMC and the FAP is handled by the full-time Resident Model Coordinator. The CAT team visits Bangladesh two or three times a year to provide overall guidance and address special issues. One of the main outputs has been a simulation with the General Model of 25 water years (1964-1989) for key stations on the main river system.

FAP 26—Institutional Development Program

The aim of this program is to develop and equip the various public and private entities that will become involved in the planning and implementation

of FAP projects. A first step in the program was taken with the establishment of FPCO which has been supported by a UNDP Project since 1990 and an extension of this support through 1994 is under consideration. The first phase will be a study to determine the tasks to be undertaken in coming years, and identify the central and local government agencies and private organizations that should be charged with these tasks. The FPCO, the BWDB (possibly through specially established units), and the Local Government Engineering Board (LGEB) will have important roles to play but other agencies will be involved and their specific contribution has to be determined. Also, many questions remain as to how these entities will be staffed and organized. The FAP has already contributed to the growth and development of the local consulting industry but there is more to be done. Of particular importance is the interaction of these institutions with the many different interest groups living in the project areas. A concept note has been prepared by the FPCO outlining issues and alternatives and the first phase study described above would begin early in 1992. The recommendations of the study should be available by mid-1992 so that arrangements can be in place for the initial FAP projects.

Guidelines for Project Assessment

The Guidelines have been prepared to ensure that FAP plans and feasibility studies adopt a consistent approach to project evaluation and impact assessment. They detail multi-criteria analysis to be used in FAP project planning and describe the approaches to be used in assessing project impacts. The aim of the Guidelines is to ensure that all project impacts, positive and negative, are taken fully into account in the planning of FAP projects. In this respect, they are an advance on previous approaches to water sector planning in Bangladesh which tended to be mainly concerned with agricultural benefits and costs and tended to overlook other impacts.

The Guidelines were prepared by the Panel of Experts, working in close cooperation with a broad, inter-disciplinary group of Bangladeshi and international experts. A first draft, prepared in mid-1990, was revised at workshops held in Dhaka and Cambridge, England before being circulated to the regional planning teams in early 1991. A revised version of the Guidelines will be issued in April 1992. An annexe on Environmental Impact Assessment (EIA), recently included in the Guidelines, outlines the steps

necessary to conduct environmental assessments of FAP regional plans and projects. It reflects current environmental policies of the Government of Bangladesh and the requirements of international donors. EIA reports will accompany each regional study and project plan. They will summarize environmental impacts both positive and negative, and define environmental management activities needed to ensure that adverse impacts are kept down at to acceptable levels.

Study of Macroeconomics

This study aims to assess the potential macro-economic impact of the Flood Action Plan, including possible multiplier effects of FAP investments on regional and national economies; impacts of the loss of capital stock on the long term growth path of the economy, the effects of risk reduction on the choice of social discount rate; and the implications of major water sector investment on the sectoral allocation of resources and overall investment planning in the economy, including foreign aid. The first phase involves a twelve-month economic modelling study being undertaken in association with CERDI at the University of Clermont-Ferrand, France. The results of this work were reviewed by a group of Bangladeshi and international economists in Dhaka in February 1992. A second phase of the project would involve further modelling studies and field surveys to collect key data on differences in economic behaviour (e.g., savings and investment behaviour) in protected and non-protected areas.

New Concepts in Water Control

Several novel ideas have been put forward in the course of the studies carried out since 1988. The first concept, compartmentalization, was put forward in the UNDP/GOB Flood Policy Study and is now the subject of the FAP 20 pilot project. This will address the problem of water management in areas protected from flooding. This is one of the more difficult problems facing planners in Bangladesh where protected areas are subject to heavy rainfall for part of the year and a shortage of water in the dry season. The pilot project will explore alternative designs for water management systems and structures, and also the involvement of the local people in planning and operating decisions.

A proposal has recently emerged from FAP 13 (O&M Study) for the design of an embankment to ease the land acquisition problem and discourage public cuts. The idea would be to create conditions similar to those found on a natural river levee. The normal practice is to keep the base width of the embankment to a minimum to save land, but in this concept a wide cross-section would be used with slopes flat enough for houses and the cultivation of fruits and vegetables. The crest of the embankment would carry a paved road, which would not only enhance the value of the adjoining land but create strong local opposition to public cuts. The people whose land underlies the embankment would have a right to the newly formed land, but have a responsibility for maintenance and protection.

FAP 13 also put forward a proposal for alleviating the adverse effect of flood control and drainage on capture fisheries. This involves surrounding beels with submersible embankments and providing connections to natural waterways. The concept has been taken further by devising an integrated water management scheme which involves the lowland farmers as well as the fishermen. A field trial is being carried out by FAP 20 and will be considered further by FAP 17.

Issues in Flood Control and River Management

Introduction

A brief survey of the technical, social and environmental issues to be faced in the planning of flood control and drainage projects in Bangladesh was presented in Chapter 2 of the Bank's report on the Flood Action Plan of December 1989. This chapter expands on that earlier survey and draws on the findings of recent studies. Over the past two years, the FAP has stimulated considerable interest, not only among those directly involved in the Plan but also in academic circles, the media and NGOs. For some observers, the flood problem reduces to a choice between an "embankment solution" and a "no embankment solution". This tends to overlook the many embankments that have been built over the years in Bangladesh and that have served a useful purpose. Other observers see the choice as being between a "structural" and a "non-structural" solution. In fact, non-structural programs such as flood forecasting and warning and flood preparedness are desirable in themselves and would supplement structural interventions where these are

feasible. Similarly, dry-season cropping cannot be considered as an alternative to flood control, since much of the remaining potential can be exploited independently of any wet-season water management. Environmental issues have also generated considerable debate and some interesting conceptual issues have arisen because FAP projects are unusual in that their environmental impact is, in fact, largely defined by their primary purpose of mitigating environmental hazards. The aim of this chapter is to elaborate on issues which arise in planning, design and operation of flood control, drainage and river management projects.

River Embankments

Embankments are central features of river management and flood control in some of the world's great river basins. Among the many rivers where embankments have proved to be an economically and environmentally sound mode of development are the Yangtze river and Yellow river in China, the Rhine, the Mississippi, the Red river in Vietnam, and the Han river in Korea. In Bangladesh, there are also rivers where the economic, social and environmental effects of embankments are clearly positive, such as the Ganges, the Gumti and some of the rivers of the Northeast. On the other hand, more difficult conditions for embankment construction are found on the Jamuna and some of the internal rivers of the Northwest and North Central Region.

In Bangladesh, the planning and design of river embankments (as opposed to coastal embankments) faces a mix of technical, social and environmental problems; these include:

a. difficulties in land acquisition due to the high population density, and the lack of replacement land and employment opportunities for those displaced;

b. opposition from those outside the embankment to placing it at a safe distance from the river;

c. unauthorized breaching of embankments during floods (known as public cuts) by those on the river side in the belief that it should lower the flood levels;

d. unstable and unpredictable rivers resulting in severe bank erosion;

e. a lack of suitable rock for bank protection and river training;

f. high rainfall in the protected areas which leads to high costs for drainage (often pumping is required);

g. interference in the movement of fish which can lead to a drop in the catch of capture fisheries;

h. relatively low economic returns since benefits accrue mainly from changes in farming practices in areas that are already intensively cultivated; and

i. possible changes in aquatic ecology and water quality in some areas.

These problems, known to water resource planners in Bangladesh for many years, attracted considerable attention in the search for viable flood control initiatives following the 1987 and 1988 floods. Therefore, the FAP included a number of components and supporting studies aimed at addressing these issues. The Brahmaputra River Training Study (FAP 1) and the studies in connection with the Secondary Towns Protection (FAP 9) are well advanced and have led to a deeper understanding of the mechanics of bank erosion and the problems of bank protection. The Bank Protection and River Training Pilot Project (FAP 21/22),would be a systematic study of alternative techniques and construction materials for protection against bank erosion. Also, the Compartmentalization Pilot Project (FAP 20) is designed to investigate methods of water control, especially drainage, in the areas protected by embankments. A number of other supporting studies, relating to the problems cited above have been completed or are at an advanced stage. In addition, new concepts are being explored concerning the alignment and design of embankments which appear to have some social as well as technical advantages.

Flood Control and Drainage Projects

The aim of a flood control and drainage project (FCD project) in Bangladesh is to modify the water regime for the benefit of the people living in the project area. This involves enclosing an area to exclude high flood levels and providing drainage to dispose of excess rainfall. The term polder is commonly used to denote an area surrounded by an embankment to exclude floods. Polders equipped with central pumping stations and conventional canal systems are referred to in Bangladesh as FCD/I projects. Sometimes, polders are equipped with pumps to evacuate water from inside the polder

when outside levels are too high for gravity drainage. Gates are also provided to release water when gravity flow is possible. Numerous polders have been built in Bangladesh; some enclose large areas such as the Chandpur Project (40,000 ha) in the southeast, and the Pabna Project (185,000 ha). In the cases of Chandpur and Pabna, and several other large polders, part of the surrounding embankment forms a flood embankment along a major river. Often the land inside is irrigated by farmer-owned low-lift pumps and tubewells.

The experience with FCD projects in Bangladesh is mixed; there have been some successes but there have also been a number of failures. These projects provide a rich diversity of experiments in the Bangladesh environment and are valuable guides to FAP planning. Therefore, two supporting studies, the FCD/I Review (FAP 12), and the O&M Study (FAP 13) have reviewed past experience. The studies conclude that the technical, environmental and social complexities of FCD projects have in general been underestimated. Also, the planning of most projects has been based on inadequate hydrologic surveys and analysis and, as a result, their intended hydrological impacts within and outside of the project area have not been achieved. This has led to frequent public cuts, overtopping of embankments, back flow in rivers and drains, erosion or siltation, and drainage congestion. Drainage problems are common due to faulty location and inadequate capacity of structures, and poorly planned and maintained drainage networks. Embankments have often been set too close to rivers and in places have eventually been retired to a safer distance.

The multiple uses of embankments and other structures needs to be more fully considered in project planning, since secondary uses can have significant benefits. In general, there is also considerable scope for improved design and construction techniques; this should not lead to higher costs since overdesign is just as common as underdesign. FCD projects have contributed to the decline in fish stocks for capture fishing but, at the same time, they have expanded possibilities for fish farming and culture based commercial fishing. The competing interests of capture fishing and agriculture have important social implications in the planning of FCD projects.

Poor operation and maintenance is a factor in the unsatisfactory performance of FCD projects. FAP 13 (O&M Study) has shown that this is often due to weaknesses in the projects' physical design and social organization and failure to involve local people in planning, design and operation. Such

involvement would help to avoid conflicts, for example, between farmers and fishermen, which can lead to damage to the project works such as cutting embankments and dismantling of gates. Problems also arise due to inadequate budget allocations and lack of incentives for project staff to specialize in O & M. Pilot projects under FAP 20 would test new design and planning concepts and, in conjunction with FAP 13, develop new approaches to participatory planning and alternative institutional frameworks.

River Training and Bank Protection

Bank erosion is a growing problem for the communities living close to the rivers, especially along the Jamuna and the Meghna. The township of Chandpur, for example, has been under attack from the Meghna for years and, although large resources have been spent in fighting the river, the risk of damage and loss of critical facilities continues to grow. Along the Jamuna, embankments are often eroded and in places, have to be retired to safe distances. The erosion problem is not flood-related since it can happen at virtually all stages of river-flow. The preferred method for dealing with an erosion problem is to divert the river away from the point of attack by means of armoured spurs. This approach requires an ample supply of low-cost rock. Unfortunately, the only source of rock in Bangladesh is in the Northeast and it is not well suited to use in river training. Alternatives such as gabions filled with bricks or concrete blocks (using broken bricks as aggregate) are costly and do not perform as well as quarried rock.

Environmental Issues—The Special Nature of FAP Projects

Any project forming a part of the FAP has the primary function of environmental improvement. There are broadly two types of FAP projects. First are the FCD projects that modify the water regime for the benefit of the rural population. The second are those designed primarily to protect cities, towns, villages and farmland from the major environmental hazard of bank erosion, but they may also include some urban drainage and flood protection. Both types of projects must be designed in such a way that they are free from any adverse environmental effects.

For an FCD-type project, the main environmental challenge is to modify the water regime so that there is no conflict between projects or between

social groups and areas within a project. Typical conflicts might involve drainage, where one area clearly benefits at the expense of another, or where farmers benefit at the expense of fishermen. Experience in Bangladesh has shown that such conflicts tend to be resolved by people taking actions that essentially restore the pre-project situation. Common ways of doing this are public cuts or by removing control gates or simply failing to operate them. In other words, any adverse effect that is clearly evident is corrected by overriding the intentions of the designers. FAP 12 showed that by far the most troublesome problems relate to conflicts (and also inefficiencies) in surface water management. Bank protection projects seldom have any adverse environmental impact. Theoretically, protection of one location might lead to attack at another location but this rarely happens in practice; the problem here is mainly to establish the technical, financial and economic feasibility of countering the awesome erosive powers of the rivers of Bangladesh.

FAP projects, especially the FCD-type projects, have environmental enhancement as their main purpose. This is in contrast to the majority of investment projects which have a primary purpose that is unrelated to, and at times in conflict with, the goals of environmental improvement. For example, projects that provide services (such as roads, bridges, powerplants, etc.) or products (such as coal mines, oil refineries, paper mills, etc.) often have adverse environmental effects. If these negative impacts cannot be eliminated, then at least they have to be mitigated to a level where they can be accepted. Thus, there is often a trade-off between the need to provide an essential service or product and the acceptance of some environmental loss. However, in the case of the FAP, the scope for striking compromises between different groups is quite limited and, therefore, adverse impacts have to be virtually eliminated.

Project-Related Impacts

The Water Regime

The primary impact of an FCD project is a change in the water regime. For example, a typical project might include an embankment to protect an area from flooding, and a system of drains and control structures to dispose of rainfall flooding in the protected area. If the system is properly designed and

operated, the farmers in the area will be able to achieve higher yields and cropping intensities. The designers use mathematical models and hydraulic analysis to simulate the effects of various schemes and compare their results before arriving at a preferred solution. But, there is a risk that the project fails to perform as predicted. For example, improved drainage in one part of the project may worsen drainage elsewhere in the project area, or the project may worsen river flooding in an adjacent area. It is such problems in the field that lead the farmers to cut the offending embankment, or take other corrective measures which return the project to a condition close to the pre-project situation. Unfortunately, it is not uncommon for farmers to act on faulty perceptions and destroy works that are not causing a problem. Hence the need for close contacts with the local people when planning a project.

Groundwater

A significant reduction of flooding in an area might possibly lead to a drop in the annual groundwater recharge. Preliminary studies in the North Central Region indicate the loss of recharge is not material for partial flood control, but may be significant with full flood control over a large contiguous area. Further studies are needed to confirm the extent of this problem. In the meantime, the implementation of full flood control on a large enough scale to affect recharge is unlikely, at least for many years.

Fisheries

In the past, agriculture and fisheries were complementary activities in floodplain areas, but with increased population pressure and intensification of agriculture, these activities now are often in conflict. Beels have been drained to provide additional land for dry-season cropping and water used for irrigation; and river embankments have been built to protect both dry-season and monsoon-season rice crops from unwanted flooding. These interventions have impinged to varying degrees on natural fish habitats and migration routes, and production from capture fisheries has gradually declined in recent years, aggravated by overfishing as fish stocks have declined. Recognizing the conflict that exists between agriculture and capture fisheries, and also the importance of fish production as a source of dietary protein and of rural employment, the objective of the FAP is to design and operate flood protection projects that will optimize agricultural and fisheries production.

Projects will have to be designed to allow controlled flooding of floodplain land without causing damage to crops, fisheries, infrastructure and urban land. Within compartments behind major river embankments, intake regulators and drainage sluices need to be managed to control the timing, depth and duration of flooding within limits that ensure secure growing conditions for crops while at the same time, allowing fish to migrate to and from their natural floodplain spawning and feeding areas. This is easier said than done, however, given the annual and seasonal vagaries of weather and floods in Bangladesh. Management plans for compartments, regulators and sluices will need to be prepared in consultation with local interest groups so as to take local experience into account and to minimize potential conflicts. Although projects should be designed to protect existing fisheries, other means to maintain and increase floodplain fish production must also be developed such as the stocking of flood plains, rivers and beels, aquaculture in paddy fields and intensive fish culture in tanks and borrow pits. Specific measures to promote such techniques need to be included in project plans, taking into account also the needs of traditional fishing communities for employment.

Sediment

There is widespread concern that flood control reduces the deposition of sediment on floodplain and thereby leads to loss of soil fertility. In fact, soil studies show that most floodplain land does not receive regular additions of alluvium since much of the flooding is by ponded rainwater. Where new sediments are deposited, they contain little organic matter or soluble nutrients that plants can use immediately, and sandy deposits may remain infertile for several years; farmers recognize that embankments can benefit them by excluding such deposits. Flooding undoubtedly provides fertility benefits, but this appears to be derived from biological activity in the water and the submerged soils. Studies are planned under the FAP to identify the sources of this nutrition and to quantify the contributions they make to floodplain soil fertility in various ecological environments.

Embankment Failure

The potential failure of embankments during a flood has been cited as an environmental concern since it poses a major threat to human lives. On the

major rivers the depth of water retained by a flood embankment is between one and two meters. Sudden failure would endanger anyone in the immediate vicinity. But seldom is the mode of failure so abrupt as to cause a dangerous flood wave and the water levels rise gradually on the downstream side of a breach. The experience in Bangladesh is that breaches are not a significant factor in loss of life during floods.

River System Impacts

One of the potential impacts of a large-scale structural solution to the flood problem would be changes in river morphology. For example, an embankment constructed along the entire left bank of the Jamuna would reduce overbank flooding. This, in turn, might mean, for a given flood, that the flow would increase in the Jamuna itself and downstream in the Padma. This might lead to increased flooding in other areas and possibly increased bank scour. The effects of confining the river cannot be predicted with any degree of certainty. Some experts predict that confinement would lead to increased bed erosion which could offset other effects so water levels may not change and even, for a given flood, be lower. Others predict aggravation of the river beds and higher water levels. In order to advance the understanding of the morphology of Bangladesh's rivers a major program of data collection and monitoring, the River Surveys Project (FAP 24), has been designed. Confinement of the Jamuna to the extent that it might raise water levels is still a distant prospect and, before any such decision is taken, much more will be known about the river.

Fears have been expressed that further embanking of the rivers in Bangladesh will reduce sediment run-off from riverine areas and, hence, deplete the flow of sediment into the delta. This seems unlikely to happen because under present conditions sediment is deposited in the floodplain rather than removed. The effect of embankments would be to increase the sediment load and, by keeping the flow in the main river, increase its sediment carrying capacity until it reaches the delta.

Water quality is a problem during the dry season when the flushing capacity of the main rivers and their distributaries is low. A major source of pollution is human wastes; urban wastes are often untreated and few people in rural areas and poor urban neighbourhoods have access to sanitary facilities. Industrial effluents are also a problem, especially around Dhaka and

Chittagong. It has been argued that flood control would reduce seasonal flushing of pollutants and thereby exacerbate the water quality problem. Waterways will not dry up as a result of flood control works and, in any event, the works could easily be designed to permit periodic flushing of the channels.

Wetlands, Waterbodies and Wildlife

Improvements in flood control and drainage will not lead to a significant loss of natural wetlands since virtually all of the lands likely to be affected have been under cultivation for centuries. Changes in some waterbodies have occurred over the years, mainly through expansion of low-lift pumping for boro cultivation. This is harmful to capture fisheries and in some areas, to wildlife. The Inception Report of the Northeast Regional Study revealed a potential problem resulting from the rapid growth in dry-season cultivation; some haors which support large flocks of wintering waterfowl could be threatened by further expansion of boro cultivation. The Asian Wetlands Bureau has been brought in to study this problem. Cultivated lands, especially paddy fields, are home to a wide variety of the flora and the fauna and studies are needed to provide a basis for assessing the impacts on these of changes in water regimes resulting from irrigation, flood control and drainage.

Social Issues

Rural development projects can seldom be designed to impact equally on all levels of the rural population. FCD and FCD/I projects clearly benefit those who own land through enhanced land productivity. There is also evidence that the landless may benefit by higher labour demands for more intensive farming, and for jobs created by construction and maintenance. The loss in capture fishing and reduction in waterborne transport (projects often include roads and bridges) leads to disbenefits due to reduced employment for fishermen, boatmen and boat-makers. In contrast, opportunities increase for pump tenders, mechanics, well drillers, carters, rickshaw drivers, etc. Sometimes those outside the project feel that they suffer more flooding and drainage congestion than those inside the project; this can lead to public cuts of the embankment. Farmers and fishermen also have conflicts over the timing of gate operations.

Land acquisition is one of the most common sources of dissatisfaction. Prices paid are not unreasonable but there are lengthy delays in payment. Moreover, the opportunities for finding replacement land or alternative employment are limited. In general, there is room for improvement in the legal and administrative procedures for land acquisition. Also, there is a need for programs to retrain or resettle those who cannot replace their land. FAP 15 has investigated the land acquisition problem and has recommended ways to improve the process.

Flood control and drainage projects in Bangladesh would benefit from more participation of local communities in their planning, implementation and management. In general, not enough effort has been made by the planners to consult local people or to take into account the interests of different groups (e.g., lowland and highland farmers, fishing and boating households, households inside and outside the project area). As a result, projects have been less effective than they might have been. Projects sometimes fail because groups that are adversely affected resort to cutting embankments and damaging regulators.

The many islands (known in Bangladesh as chars) along the course of the main rivers are estimated to have a population of 1.5 million. Not only are the lands prone to severe flooding and bank erosion, but their isolation leads to insecure living conditions through difficulties in providing government services and emergency relief. However, given the pressure on available land, it is impractical to consider removing the present population and preventing further settlement. Therefore, ways to improve living conditions for these people should be explored as part of the regional studies. There are reports that communities in some of the chars on the Jamuna oppose any interventions such as the Jamalpur Project on the grounds that it will increase the flood depths. These fears are possibly exaggerated; at low floods, the river would barely reach any new embankments that might form part of the Jamalpur project, and at high floods the reduction in overbank flow would be negligible compared to the vast flows in the main channel. Nevertheless, this points to the need for close consultation with those who feel that their interests are threatened by interventions in the water regime.

Economic Issues

In Bangladesh, under present conditions, the primary justification for flood control and drainage rests on achieving more productive use of land and wa-

ter resources. While some economic gains can come from avoidance of occasional flood damage, the main source of benefits lies in modifying the water regime so that the Bangladeshi farmer can consistently achieve higher yields and cropping intensities on his land. Outside of the Northeast, most of the areas subject to flooding from rivers and rainfall have cropping intensities of between 160% and 180%. There is the potential for farmers to bring their intensities up to an average of 200% and at the same time to increase yields by switching to T. aman from B. aman and to plant more HYVs. The main impact would be on the wet season crop since the area planted to a boro crop is in general independent of flood control measures, although in some areas, embankments are needed to protect the boro crop from early floods. In general, therefore, the per hectare returns from flood control and drainage will be fairly low. Fortunately, however, FCD projects can be designed to protect large areas with low-cost infrastructure and this leads to low per hectare costs and as a result, reasonable economic rates of return are attainable. A problem arises, however, in those projects where the need for drainage of excess rainfall coincides with high flood levels outside of the project. This creates a need for pump drainage which can raise significantly the capital and operating costs and render a project uneconomical.

It has been argued that the justification for flood control and drainage should not rest solely on the economic rate of return. Certainly, flooding on the scale of 1988 has social and health impacts, beyond the direct losses to crops and property, that are significant but can not be easily quantified. The Macro-economic Study has been designed to address these broader impacts, and the results of this study may argue for some discretion in setting a level for an acceptable rate of return for flood control projects.

Future Outlook

Objectives and Approach

Over the past two years, the FAP has provided a framework for a wide range of investigations into the technical, economic, social, and environmental issues to be faced in formulating plans for river management, flood control and drainage. These issues, many of them enumerated in the Bank's 1989 report on the FAP and further elaborated in of this paper are now more widely understood and accepted. At the same time, there has also been

considerable progress in developing the tools and techniques needed to pursue a systematic multi-disciplinary approach in the search for ways to alleviate the flood and drainage problems of Bangladesh. Some of the main areas of progress are enumerated below:

a. The problems and potentials for water control are being examined in a regional context so that proposed schemes will be planned as a part of comprehensive and integrated regional plans (FAP 2 through 7).

b. Surveys of existing flood control and drainage schemes have provided an objective view of the strengths and weaknesses of these schemes and will be a valuable source of future reference for all disciplines involved in water control planning (FAP 12 and 13).

c. Alternative approaches and improved procedures for land acquisition and resettlement are being explored (FAP 15).

d. Analysis of the interaction between water control works and capture fisheries, and its social consequences have high priority in regional and project planning studies; a major program of investigations and pilot projects is in progress (FAP 17).

e. Recent studies of river behaviour in relation to bank erosion have greatly enhanced the understanding of this problem and will lead to project proposals to deal with the more urgent sites (FAP 1 and 9).

f. The technical basis for the FAP is being strengthened by improved data collection and analysis such as Surveys and Mapping (FAP 18), Geographic Information Systems (FAP 19), and the River Survey Program (FAP 24).

g. Pilot projects to test new approaches and concepts include: River Training (FAP 21); Compartmentalization (FAP 20)); and Flood Proofing (FAP 23). These will draw on many of the activities mentioned above.

h. "Guidelines for Project Assessment" developed under the FAP provide guidance for economic and social evaluations and for environmental impact assessments following national and international standards.

The approach of the FAP will continue to be one of a thorough, objective and scientific analysis of all reasonable options and strategies, with special emphasis on social and environmental dimensions. The

physical, social and environmental differences between and within regions dictate an unbiased approach to a range of options and a search for new concepts. Every year, somewhere in Bangladesh is hit by severe floods causing suffering and loss to those who can least afford it and, from time to time, vast areas and millions of people are affected by such events as the 1987 and 1988 floods and the 1991 cyclone. The FAP was established by the Government and friendly countries to find ways to mitigate these natural disasters. Unfortunately, there are no easy or early solutions. A short-term "crash program" of large-scale engineering interventions is not a feasible proposition. On the other hand, doing nothing and "living with the floods" is not an acceptable policy, nor is a reliance solely on non-structural measures. What is needed is a deliberate, staged approach employing a range of interventions each carefully designed to suit local conditions.

Future Scope and Content of the Flood Action Plan

Coordination with the National Water Plan

As on outcome of the 1987 and 1988 floods, the FAP is in principle concerned only with wet-season water control. However, in practice, the FAP has come to cover much wider aspects of year-round land and water development. This is because a number of components which predated the FAP have been included, either to take advantage of the FAP's quality control and procurement procedures, or because of a logical relationship to the FAP's objectives. For example, three of the regional studies (Northeast, Southeast and Southwest) are comprehensive studies of year-round water management and much the same can be said of the Cyclone Protection Project. Also, many of the supporting studies have wider applications than flood control or drainage; for example, surveys and mapping, fisheries, surface water modelling, river surveys and GIS. In this connection, it is to be noted that a unique feature of land and water resource development in Bangladesh is that irrigation is largely a private sector activity with most of the land being irrigated by farmer-owned tubewells or low lift-pumps. Thus, the role of the Government in the water sector is primarily to provide the infrastructure to support the private sector, and this mainly involves the type of flood control and drainage (FCD) projects falling under the scope of the FAP. According to the recently completed National Water Plan Phase II, FCD projects would account for the bulk of future public investment in

water resource development. Therefore, a widening of the scope of the FAP to contribute to the further elaboration of the NWP is a matter for consideration by the Government and interested donors. Initially this would require some revision of the scope of the Northwest and North Central regional studies to cover year-round water control, and in the longer-term it would require closer coordination and realignment of responsibilities of the FPCO, the BWDB and other agencies already cooperating in the FAP. Bringing together the FAP and the NWP would have the advantage that all water resource planning would then benefit from the FAP's multi-disciplinary approach and its procurement and oversight procedures which, although still evolving, are a marked advance over past approaches to land and water resource development in Bangladesh.

Flood Action Plan Projects

Over the next three years, the FAP will move into the project phase by building on the work of the past two years. Of the eleven main components (see Table), six have moved into the project preparation stage and the projects which are emerging are:

a. River bank protection at key locations on the Jamuna and the Meghna (FAP 1 and 9B)—to be appraised by the World Bank in mid-1992;
b. Dhaka Integrated Flood Protection (FAP 8B)—recently appraised by the Asian Development Bank;
c. Secondary Towns Protection (FAP 9A) to be appraised by the Asian Development Bank in mid-1992;
d. Reconstruction of Coastal Embankments (FAP 7), to begin in 1992 with financing from the World Bank, EC, Saudi Fund and Japan; a larger, second phase project is being prepared under FAP 7 for 1994;
e. Flood Forecasting and Early Warning (FAP 10)—under implementation; and
f. Flood Preparedness (FAP 11)—being prepared.

In addition to these investment projects, three pilot projects would be active in 1992 and beyond:

a. River Training and Active Flood Plain Management (FAP 21/22);
b. Compartmentalization at two sites (FAP 20); and
c. Flood Proofing (FAP 23).

The regional studies have so far identified three new FCD projects which would be studied in more detail over the next years:

a. The Gaibandha Project in the Northwest Region covering about 100,000 ha;
b. The Jamalpur Project (FAP 3.1) in the north of the North Central Region covering about 90,000 ha; and
c. The North Noakhali/Dakatia covering about 140,000 ha in the Southeast Region.

However, before these projects can be considered as ready for appraisal by financing institutions, some complex technical, social and environmental issues need to be addressed in their planning and design. Furthermore, the priority for new FCDs would have to be measured against the need to improve the existing FCDs which have not performed as planned.

Regional Studies

The six regional studies (counting the Cyclone Protection Project as a regional study) will continue to be key elements of the FAP. Over the next year, an assessment of options for flood control and drainage in each region should be completed in sufficient detail to identify broad regional strategies and a list of priority projects. This assessment will also include recommendations for dealing with those existing FCD projects which have significant problems. The current scope and funding of the Northwest and North Central regional studies should be expanded to provide a more comprehensive coverage of land and water resource development to bring them in line with the other regional studies. The coverage of regional studies will be expanded to cover the Meghna estuary (FAP 5B) and possibly the Chittagong Coastal Area (FAP 5C). The regional approach should become a permanent feature of land and water resource planning in Bangladesh. In fact, the regional studies should be the primary source of projects for the rapid build-up of FCD projects over the next five years foreseen by the National Water Plan.

Supporting Studies

Of the fourteen supporting studies, five are essentially complete or would be completed in the first half of 1992. These are: FCD/I Agricultural Review

(FAP 12); the O&M Study (FAP 13); the Flood Response Study (FAP 14); Land Acquisition and Resettlement (FAP 15); and the Environmental Study (FAP 16). The findings of these studies have been made available to the study teams through draft reports and participation in workshops held in Dhaka. This has allowed a wide range of views to be considered in finalizing the reports. These studies have provided valuable insights to many of the technical, social and environmental issues relating to FAP projects and have provided inputs to the "Guidelines on Project Assessment". Two studies, Fisheries (FAP 17) and River Surveys (FAP 24) will enter a much more active phase in the near future. There will continue to be a growing demand for the output of Surveys and Mapping (FAP 18), Geographic Information Systems (FAP 19) and Flood Modelling (FAP 25). A second phase of FAP 13 and the Institutional Study (FAP 26) would begin in early 1992.

Environmental Impact Assessments

FAP projects have the primary aim of environmental improvement and hence many of the regional and supporting studies, and a significant part of the consultants' inputs have been directed towards environmental issues. The detailed preparation of FAP projects involves a wide range of disciplines working together. For a typical FCD-type project, the hydrologists and hydraulic designers are responsible for ensuring that successful flood control or drainage in one area does not create a problem in other areas. The agronomist and agricultural economist have to estimate how a modified water regime can yield benefits to the farmer. The challenge of maintaining or improving the fish catch is the job of the fisheries specialist. The sociologist has the responsibility of assessing the impact of the project on different social groups and identifying ways to maximize the benefits for the rural poor. These specialists, and experts in other fields (public health, forestry, aquatic plants, water quality, etc.), have to work as a team in close contact with the local people to produce a project where there is a strong chance that the environmental and social outcome will be substantially positive and the economic return acceptable. The project must also include a practical and workable plan for the operation and management of the project in concert with the beneficiaries.

The draft feasibility report produced by this multi-disciplinary effort will include technical proposals as well as detailed statements of the project's

economic, environmental and social impact. Under FAP procedures, the report will be subjected to an independent review by the FPCO, POE, CAT team and other experts retained as necessary. The feasibility report will then be revised, where necessary, and produced as a final report. While this final report will provide a detailed environmental treatment of the proposed project, it will not alone meet the needs of an Environmental Impact Assessment (EIA). Therefore, the consultants will be required to follow the guidelines for EIAs set out in the Guidelines for Project Assessment. This EIA guidelines sets out procedures for project formulation and analysis which meet national and international standards. These procedures for the EIA will overlap, in many areas, the normal processes of a feasibility analysis since both aim to produce an environment ally sound project. However, the EIA procedures reinforce the feasibility report and at the same time ensure that the EIA would be acceptable to potential financing agencies.

Public Participation

A new approach to project planning, implementation and management for the FAP is needed which involves the active participation of local communities. Local people must be involved in the identification and planning of projects, and plans for the effective operation and maintenance of the project should be decided with the local community and local councils before implementation starts. Conflicts of interest between different groups in an area must be identified early and taken into account in project design, and households that will be adversely affected must be identified early and compensatory measures built into the project design. During implementation and afterwards, every effort should be made to target project benefits to those adversely affected and to the rural poor in the local area. If projects are to succeed, local communities must be involved fully in project planning, implementation and management and feel a sense of ownership.

Such participatory approaches will not be easy to implement in Bangladeshi communities where there is such a diversity of interest groups and where the more influential groups sometimes try to manipulate government programs in their own interests. In order to help tackle these problems, preliminary "Guidelines on Participatory Planning" are being prepared by FPCO, based on experience gained in various innovative

programs in Bangladesh. Also, the Compartmentalization Pilot Project (FAP 20)) is testing alternative approaches to participation. Both of these initiatives will involve close collaboration with NGOs. Related to the question of local participation is the need for informed public debate about specific projects and the FAP program as a whole. Despite the large number of FCD projects implemented in Bangladesh since the 1960s, until recently there were few thorough evaluations. Thus, the reasons for success and failure were not identified, lessons were not learned and taken into account in planning other projects, and the overall investment in the sector was less effective than it might have been. Public debate about water sector projects, which have accounted for over 10 percent of government development expenditure since Independence, was limited and sometimes poorly informed.

The FAP has undertaken the first comprehensive evaluation of the economic, social and environmental impacts of FCD projects (under FAP 12 and other supporting studies) and the results have been widely discussed and disseminated, and incorporated in the Guidelines for Project Assessment to be used in the planning of all FAP projects. A program of public presentations of all planning and supporting studies will be carried out in the next phase of FAP, and an information resource centre will be established at FPCO where interested parties can review FAP reports and discuss them with planners.

Action Plan Implementation

The FPCO has been the government agency responsible for coordination of the FAP since late 1989. It has done an excellent job considering the unique nature of its task and the diversity of work being conducted under the various FAP components and studies. Its record in handling the government formalities needed to mobilize a team of consultants is outstanding when compared with past experience-the elapsed time between inviting proposals and fielding a team has averaged a few months instead of several years. A two-year extension of the UNDP project supporting the FPCO is being processed. While considerable progress has been made under the FAP in mobilizing and coordinating technical services, the next challenge will be to improve implementation and management of the projects generated by the FAP. Public works projects in all sectors in all sectors in Bangladesh commonly experience lengthy delays through problems in procurement,

budgeting, etc. Work will begin shortly on the Institutional Development Program (FAP 26) which will seek ways to improve the performance of all central government and local government agencies involved in the planning, design, construction, and operation of FAP projects.

A number of non-governmental organizations (NGOs) in Bangladesh are involved in water development projects. Among their many activities in the rural areas, they organize groups of the rural poor to contract for project works and promote the use of women in routine maintenance. There is further scope for NGOs to participate in the FAP through interaction with the teams engaged in the regional and supporting studies, and in participatory planning and exploring new approaches to closer public participation.

A Long-Term View

The projects identified in the current phase of the FAP will mainly be implemented during the period 1995-2010 and beyond. Regional plans must try to anticipate the changes in social, economic and environmental conditions in this time-frame and how they might affect the future needs for flood protection and drainage. Current projections suggest that Bangladesh's population will reach 150-170 million by 2010. Since agriculture seems unlikely to absorb more than about 30% of the incremental labour force, the remainder will need to find employment in commerce, industry and services. This will lead to an acceleration of rural-urban migration rates, and it is predicted that the urban population might reach 15-50 million by 2010. Those trends have a number of implications for the FAP.

Urban housing and infrastructure will become much more important than in the past, adding significantly to the investment value of property and services needing protection from floods. Urban and infrastructure expansion will taken large areas of agricultural (and village forest) land out of production and, thus, increase the need to intensify food and fuel production on the remaining land. Additionally, it is envisaged that a greater proportion of land than at present will be devoted to producing market garden crops, cultured fish and dairy products to feed the growing urban populations (whose food demands differ from those of rural populations). In turn, this will require cereals' production to be intensified on other land. Increasingly in the future, these forms of intensification will need to be sought in the

kharif season. That is because, before 2010, the potential will have been reached for further expansion of small-scale irrigation in the dry season on which the rapid rate of food grain production in the past two decades has largely been based. The greater production will likely increase the demand for reliable flood management. At some stage, this may make pump drainage an economic proposition.

Urban and industrial expansion will add to existing problems of urban drainage, sanitation, water supply and pollution, which will need to be addressed in project planning. Intensified agricultural land use and aquaculture may also have adverse environmental consequences. These will have to be anticipated in project planning so that mitigatory and monitoring measures can be included in project designs. Finally, the growing pressure of population on land and water resources will further increase the pressure on wetland and wildlife resources. Appropriate conservation measures need to be identified, assessed and implemented as soon as possible so as to reduce the scale of irreversible environmental degradation, to the extent that is practical in Bangladesh's demographic and socio-economic situation.

CHAPTER SEVENTEEN

FLOOD PLAIN AGRICULTURE*

M.M. Rahman

Section 1

Highlights of the Discussion on Flood Plain Agriculture

The traditional concept of *food* from the flood plain must be redefined away from the restrictive notion of cereals alone, towards other vital components of Bangladeshis' diets (as well as livelihoods) which are potentially available from increased flood plain productivity.

In terms of the past track record of securing food and livelihoods in the flood plain, the adoption of High Yield Variety (HYV) seeds, fertilizers and minor irrigation have made much greater contribution than Flood Control and Drainage (FCD) and Flood Control, Drainage and Irrigation (FCDI) projects. These relative contributions should be seen in the context of: minor irrigation covering 2 million hectares or 22 per cent of the net cultivated area whereas FCD covers 2.6 million hectares or 28.7 per cent of the net cultivated area and FCDI covers only 0.3 million hectares or 1.37 per cent of the net cultivated area.

Available time series data over the last four decades suggest that as more and more embankments have been added in the flood plain, the area flooded during catastrophic floods has in fact, paradoxically *increased viz.*

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*This article was published by BARC (Bangladesh Agricultural Research Council), Dhaka in November 1989.

1954 = 12,000 sq. miles, 1955 = 14,000 sq. miles, 1974 = 20,000 sq. miles, 1987 = 22,000 sq. miles, and 1988 = 30,000 sq. miles—possibly because flood water has been diverted towards new areas (or, because, natural drainage has been impaired).

Water control structures are ritually justified on supposed cost-benefit grounds in terms of their incremental benefits to agriculture i.e. *in the name of agriculture*. However, such a view is not confirmed by the agronomists actually working in the field of agricultural development.

While embankments might be justified for protecting vital structures such as urban factories and rural infrastructure, this does not detract from the consideration that the performance of FCDs in agricultural development remains insignificant and as yet unproven in cost-benefit terms, even though the benefits may appear deceptively high.

There is a growing apprehension that an attempt is being made in the name of FCDI to transform Bangladesh into *a land without water*. However, the issue should rather be how to maximize the use of water at the lowest cost in the different agro-ecosystems of the country. For example,the lowest cost should investments be made to support irrigation with ground water during the non-flood period, or should they be made to exclude surface water in the flood period? The available evidence to date suggests that expected rates of return which were estimated for FCDI projects have not been achieved in practice. For instance, the potential rate of return of 16 per cent which was projected earlier for the Chandpur Irrigation Project is now thought to be of the order of 5 per cent and the potential rate of return of 24-30 per cent projected earlier for the Muhuri Irrigation Project is now thought to be 10 per cent. Even the rates for FCDI projects estimated earlier are low compared with the potential rates of economic return from ground water irrigation in the flood plain (e.g. STWs with 211 per cent) or from other surface water users (e.g. integrated agriculture and fisheries 105 per cent).

There remains considerable confusion with regard to the different concepts of flooding: normal annual flooding, below normal annual flooding and the 1988-type catastrophic flooding. It is crucial that a clear distinction be made as to whether planned interventions are to cope with all, some or any single one of these concepts of flooding. The Achilles heel of the embankment approach is that even with a complete system of walled embankments, it is still impossible to provide effective protection against externally induced, catastrophic coincidences, of flood peaks such as in

1987-1988. Floods in Bangladesh are a reality that, in a sense, have to be accepted. However, such acceptance should be guided by the conscious principle of maximizing the benefits and minimizing suffering. In fact, abnormally high flood waters actually get inside the massive flood control structures and cannot escape. Hence *river training* may present a more viable option for coping with flooding. Furthermore, irrespective of flood control structures, early flood warning systems for disseminating information to remote villages and *char* dwellers should be developed on the basis of existing forecasting systems.

There is considerable concern over the significant *second generation* problems, which include:

- Water logging through lack of drainage on the lower land levels, occurring both inside and outside the polders;
- Increased flood depths in non-poldered areas;
- Downstream siltation and the dying of perennial surface water resources;
- Decline in soil fertility inside polders, such as in the Ganges-Kobadak Scheme, because of sulphur and zinc deficiencies and the reduced benefits of potassium and nitrogen formerly deposited from flood-borne blue green algae and flood sediments;
- Obstruction and decline of inland water transport, in both actual and potential terms;
- Embankment breaches through river erosion and farmers' actions are common throughout the country and social conflicts often occur over breaches in the shrimp-growing coastal polder areas;
- Farmers with insufficient understanding of new water regimes are unable to adjust to the new farming systems;
- Reduced benefits of floods in terms of pest control like Bandicoot rats (*Bandicota bengaliensis*) and removal or reduction of fish and prawn nurseries, breeding grounds, and harvest areas in the *beels* within the FCD areas.

The recent history of the Bangladesh flood plain has been one of attempted manipulation of the environment towards proposed ends. However, the full ramifications, as well as the inadvertent agronomic, social, economic and environmental effects of water control structures on other flood plain components, especially, fisheries and forestry, have not been often fully comprehended by policy-makers.

Historically, for the children of the poor, fish provided the major, if not the only, source of animal protein. The traditional diversity of Bangladesh's aquaculture resources (257 fish species and 20 prawn species) has already been drastically reduced in certain areas, as a result of constructing polders and embankments. If this trend continues, both fish and aquatic plant species will be lost altogether. Compensatory hatcheries and nurseries would require considerable additional investments and could do little to compensate for the loss of the anadromous and catadromous movements of many fish such as the *Hilsha* and prawns like the *Golda Chingree* (*Macrobrachium rosenbergii*). Structural interventions like the Muhuri Irrigation Project have thus left scores of fishing villages in decay because of the resultant lack of employment in the fisheries sector. Even submersible embankments such as those in Sylhet, despite having considerable benefits, have nonetheless led to the incurrence of environmental costs in terms of depleting the mix of fish resources.

Elevated lands such as roads, railways, embankments, ridges and homestead sites within the flood plain, both inside and outside embankments, provide the environment with productive options for forestry and horticultural crops. These higher tracts are normally free from flooding during minor floods and even in the highest floods they are usually flooded later and drained earlier. Such conditions allow a different mix of vegetables and other crops to be grown—as an additional option—than is possible on lower land levels.

Because surface water is often a common property resource (CPR) which is equally accessible to the poor, rather than being privately owned, such as land (where access is skewed towards the rich), the productivity of these common property resources has been eroded more than if they had been privately owned. This depletion of CPRs raises a number of problems which are linked to equity issues:

- The reduction of harvests from capture fisheries in the Atrai, Sylhet, Gopalganj and Barisal Basins. These capture fisheries still engage over 50 per cent of members of rural households (farmers and landless) in the lean season;
- The decline in aquatic life, like snails, turtles and clams. These are gathered for subsistence by the poor and they also use them for poultry-rearing and lime-making;

- The loss of access to the harvesting of aquatic plants by the poor such as reeds and cane for mat-making and furniture;
- The loss of water in the form of soil moisture which is necessary for rice production by poor farmers who traditionally augment their nutrition and income by growing local *boro* near inland water bodies in the dry season in non-irrigated areas.

While the World Bank's "Bangladesh: Action Plan for Flood Control" makes patronizing references to the valiant Bangladeshi farmer, the extraordinary *heterogeneity* within the set of Bangladeshi farmers in terms of their respective resource endowments is smoothly glossed over. Also lost from view are the differences in the suffering from the differential impacts of flooding: the differential access of farmers to the benefits of flood control measures; farmers' differential responses to flooding, as well as the exogenously determined access to water and ecological reserves, amongst other CPRs. Different types of farmers cope with various natural and/or man-made hazards, whether catastrophic flooding, and even drought, with a wide variety of responses. Such differential attitudes and reactions to risks at the micro-level can generate widely divergent *profit maximizing* behaviour on the part of different classes of farmers. These complexities influence macro-level outcomes in terms of conflicting behavioural patterns amongst farmers in the flood plain.

Recommendations

The discussion forum must express its considered reservations on the directions provided in the document. "Bangladesh: Action Plan for Flood Control" dated November 7th, 1989, to the Government of Bangladesh.

The World Bank should reconsider its report and critique it in the light of the deliberations of the BARC discussion forum, as indicated above.

The World Bank's "Bangladesh: Action Plan for Flood Control" represents a compromise between the UNDP Flood Study and the Eastern Waters Study. It is this sort of compromise which leads to logical discrepancies within the plan document itself. There is thus, the need for a new independent review which provides a comprehensive and in-depth comparative analysis of the agricultural, socio-economic and environmental implications of all the available flood reports.

The stages outlined in the Action Plan should involve an added dimension, i.e. regional benchmarking of survival options data aimed at augmenting the resources needed for steady productivity growth by poor rural households.

Issues relating to homestead agriculture, horticulture, and forestry on raised areas, are absolutely crucial to the survival of landless farmers who have no other resources except their own labour and homesteads. These issues should, therefore, be discussed in the Action Plan since, in a sense, the homestead can function as *a lifeboat during floods*.

The whole notion of 'rapid appraisals' and short term 'pilot projects' preceding construction and other intervention are *ipso facto* and most unlikely to capture the entire range of relevant phenomena under consideration. These include possible patterns of flooding, agriculture, socio-economic changes, as well as climatic and other environmental shifts. The studies and interventions proposed in the Action Plan are unlikely to be able to capture the whole spectrum of flooding possibilities. On the contrary, what is required is continuous monitoring and reappraisal of the Plan, so as to take account of continuous feedback and possible corrective actions whenever necessary.

The need for embankments remains as yet unproven, in the general case. This is also suggested by certain senior-level engineers' reports. However, this does not detract from the merit of embankments in particular areas where there may be location-specific advantages (and disadvantages) of their role in flood control.

As such, it is recommended that consideration of a range of investment options wider than only embankment construction should be continued to be pursued beyond the imminent December meeting in London. No closure of final options should take place at this date or stage. A strong alternative investment priority, avoiding many of the problems inherent in structural approaches, might be to encourage short-maturing, HYV *aman* rice like the new BR22 and 23 varieties which can be planted in late September when floods (if any) recede and then be harvested in December.

No physical construction is planned in the Action Plan before 1992. There is thus considerable room for manoeuvre in terms of reconsidering the real investment needs of different types of farmers, as well as other beneficiaries, in the various district agro-ecosystems of the flood plains of Bangladesh.

Perceptions of floods and flood control are national rather than partisan issues. Whatever plans and policies are eventually adopted, the consequential tax burdens will have to be borne by the common people. Hence, fully participatory discussions encouraging the freedom of a wide spectrum of opinion of flood control issues should be encouraged, prior to the taking of any major decisions.

A realistic pre-investment plan for flood plain agriculture (Section II) must integrate *macro-level* public decision-making (as exemplified in the land water resources model of the Master Plan Organization (MPO) and *micro-level* farmer decision making models in different risk prone agro-ecological zones (as should be developed on the Farming Systems Research Sites). Such integration is crucial if flood plain risks are to be overcome and profits maximized.

Knowledge of the water regime should be developed in a rigorous and scientific manner in order to support investments in flood plain agriculture rather than being a fad resulting from the media's portrayal of flooding as particularly affecting critical urban areas, inclusive of residences of the donor community.

Now that the agricultural, socio-economic, and environmental issues have been raised, a team effort with interaction among professionals from the different disciplines involved, including engineers, is called for. Such a step would serve to coordinate research from different perspectives and to bridge the gap between the single-track focus on embankments and its antiethical perspective of only focusing on crops, fisheries and livestock. This interactive team effort might be better able to support improved and more comprehensive, policy-making for flood plain agriculture.

Meaningful exercises on the comparative rates of return from the whole range of possible mixes of structural and non-structural investments in the flood plain require that evaluation studies be carried out in parallel with such investment activities. Such a procedure would ensure continuous updating of the *average* and the *marginal* rates of return over time, as well as in comparative terms.

Special efforts should be made to encourage the much higher rates of return from fish production, or fish-cum-rice production, in the nation's water bodies—reservoirs, canals and rice fields.

Investments to improve productivity within the flood plain should seek to 'relocate' productive activities—e.g. crops, fisheries, and homesteads-*in*

space and time—such that the effects on the poor, of even extraordinary flooding are minimized.

Horticulture on the homestead and other higher land crops provide a large proportion of minor food crops, and offer considerable opportunities if supplied with post-flood support such as vegetable seeds.

Geographic Information Systems (GIS) should be used to simulate possible alternative investment scenarios. For greater sensitivity, such exercises should take account of: the different combinations of cereal output, the non-cereal output, the utilization of non-market food collection, the non-farm income sources, etc., corresponding to the major flood plain agricultural alternatives, as part of the stages envisaged in the Action Plan.

Research investments in soil-crop-water management, genetic/agronomic manipulation, cropping pattern manipulation, flood water harvesting for the dry season and supplemental irrigation, should be made in order to explore options for increasing the low productivity flood plain agro-ecosystems:

- Tidal flood plain (2.85 mha of NCA).
- Active young flood plain (0.53 mha) and
- Flood basins (0.35 mha).

Although the actual hydrological characteristics of other flood plain analogous to those of Bangladesh (e.g. the Mekong, Hwangho, Indus, Euphrates, Mahananda, Chao Phrya, Mississippi, or Rhine) may differ significantly, much may be learned from comparative studies of the responses to flood control actions by different types of farmers and other beneficiaries. Equally invaluable, could be a comparative understanding of the socio-economic and environmental implications of purposive human interventions in the different flood plains of the world.

Section 2

Flood Plain Agriculture

Foundations for an Investment Plan for Agriculture in Risk-prone Environment of Bangladesh

Historically, civilisations have emerged and flourished in the fertile flood plains of the world such as the Nile, Mesopotamia, Indus, Chinese Mekong

and the Ganges, Brahmaputra and Meghna flood plains. In these flood plains, concentrated investments and human efforts have aimed at the domination of the hydrological regime for the benefit of agriculture with higher productivity. The rivers and ground water of the flood plains have been manipulated to provide irrigated agriculture and fisheries. Efforts to impound, deviate and canalise, water channels and water bodies continue to the present day. To the environmental impacts of hydraulic engineering, must now be added the additional hazards of agricultural, domestic and industrial chemicals. Poorly managed flood plain environments have deprived fisheries of living space and the means to complete their life cycles. Poor management of the resources of the flood plains have left farmers at risk to both floods and droughts. The investment challenge of flood plain agriculture is to maximise the opportunities inherent in the seasonal flood conditions that exist in the Ganges, Brahmaputra and Meghna basins of Bangladesh.

Eighty per cent of Bangladesh may be classified as flood plain. The MOA Flood Recovery Plan of 1987 evolved a dual strategy.

> "The weaning of agriculture away from the flood-vulnerable Kharif I and Kharif II seasons, into the more stable *rabi* season with expanded irrigation technology will continue. However, access to food for the increasing numbers of poor agricultural households living in flood-prone environments, with insufficient capital to adopt the more stable *rabi* season development strategy, necessitates a second vulnerability reduction strategy. This second strategy should provide "a safety net" for poorer agricultural households in risk-prone areas to develop flood or drought-tolerant farming systems so as to provide improved agricultural income and employment for the nation."

MOA and GOB have already released the impetus for expanded irrigation in the *rabi* season. Now it is the time to move investments beyond flood recovery towards a strategy for all seasons, pushing the intensive margin seasonally towards the flood areas. Flood plain investment should also exploit the massive resources of the high risk, but high potential, monsoon agriculture in the flood plains. The flood plains of Bangladesh should be zoned according to the probability and type of risk where the fisheries resources are among the richest in the world with over 300 aquatic species. Integrated agriculture/aquaculture or farming and fish culture in the flood plain environment are parallel activities contributing to the improved livelihood of rural households.

BARC studies on farming systems sites have already suggested the very high returns per hectare from combined, livestock (e.g. ducks), aquaculture and crops. Both ducks and fisheries have large export potential as evidenced by the growth of fish exports from $19 million in 1977-78 to $140 million in 1987-88. Modern technologies and improved cultural practices also provide the potential for large labour absorption, e.g. some shrimp farms support 223 man-days of labour per hectare, as well as the potential for semi-skilled labour in the complementary transportation (water and land) and agro-processing sectors adding further value within Bangladesh to export. Investments in flood plain agriculture require not only direct investments in the farming systems of the flood plain, they also require investments in the rural infrastructure necessary to increase the resilience of flood plain agriculture e.g. rural electrification, roads, inland water transport, markets and agro-processing facilities. Together, this requires the coordination of informed policy-making relating to agriculture but beyond the agricultural sector. It requires the involvement of the Ministries of Irrigation, Fisheries, Livestock, Road and Highways, Energy, Finance and Environment. Investments in flood plain agriculture require a thorough analysis of Bangladesh's comparative advantage in obtaining higher productivity, higher returns with higher inputs as Bangladesh flood plain agriculture changes amidst the liberalising of international trade and the effect of rapid urbanisation changing patterns of demand.

Foundations for an Investment Plan for Flood Plain Agriculture

A sustainable development strategy as the basis for a massive investment plan in flood plain agriculture cannot be made on perceptions and hunches. It should be grounded on solid concepts and people must deal with the empirical data. The following preparatory activities are required to encourage and direct the investment action programme.

* Establish a computer assisted flood plain monitoring network to establish time series data on the potential returns, productivity, equity, stability and sustainability of flood plain agriculture.
    - Coordinate in the different agro-ecological zones farming systems sites (FSR-BARC), stable resource and socio-economic monitoring

sites (MPO) and extension demonstration sites (DAE) with other monitoring activities, e.g. SPARRSO etc.

- Monitor resource availability, the water regime and resource use.
- Monitor farmers' and labourers' (male and female) responses to both flooding and drought over time.
- Monitor farmers' innovative practices before, during, and after different patterns of flooding and in different risk situations.
- Monitor farmers inter-seasonal strategies and responses to varying water regimes, resource availability and the availability of traditional and modern technologies.
- Monitor the dynamism of socio-economic conditions over time, including production levels and the prices paid and received, etc.

* Develop economic models of alternative flood season agriculture using this information to predict the potential returns from investment in flood plain agriculture.

- Develop static or snapshot data covering larger flood plain uses through field surveys along transects.
- Develop, using geographic information systems, an integrated flood plain data base for selected flood plain areas that encompass both the transects and the monitoring sites. This large area data base would assist area development planning and would include:
  - infrastructure
  - topography
  - flood depth, timing and frequency data from simulation studies and hydrologies data analysis
  - cropping patterns, sequences, yields and input use
  - resources (soils, water)
  - socio-economic data.
- Identify the changes that have occurred over long time periods in the flood plains of Bangladesh to determine the reasons for the booms and slumps in flood plain agriculture.
  - changes in water regime and water management technologies

  - changes in varieties, practices and productivity
  - changes in access to inputs including electricity, energy, credit, pesticides, fertiliser and information etc.
  - changes in annual cropping patterns, sequences
  - changes in the agrarian structure and resulting investment patterns
  - changes in the marketing systems and rural infrastructure as a result of roads, railways and boats
- Document the changes in farmers' strategies and responses to flooding.

* Flood Plain Zoning-according to the impact of different types of floods e.g., flash flood etc. on agricultural production and fisheries.

* Develop technologies for flood risk management
  - crops/varieties/cropping patterns.
  - agronomic management practices.
  - dryland farming techniques.
  - crop diversification.

* Design agro-technology transfer systems for flood-prone areas
  - rehabilitation programmes.
  - alternative management systems.
  - new national systems for the transfer of technologies.

* Evaluate the on-going investments to reduce floods and increase productivity (including water control infrastructure)
  - Changes in the water regime.
  - Impact on wet and dry season agriculture.
  - The responses of farmers to the introduction of water control facilities and the factors affecting farmer responses.
  - Identify the factors affecting performance in terms of water management and beneficial changes in the water regime.
  - Operation and maintenance of water control systems.

- Participation and involvement of local institutions and beneficiaries in water resource development.
- Overall economic returns.

* Aquaculture in flood plain areas:

- Documentation of the potential resources and management of the flood plain fisheries.
- Estimation of the present use of fisheries and their potential productivity.
- Estimation of the present and potential linkages between aquaculture and agriculture.
- Determination of the management needs for the maintenance and enhancement of flood plain aquaculture.
- Documentation of the factors related to aquaculture which affect farmer behaviour in agriculture (apart from inter-cropping) and assessment of how these areas of activity are linked and how the linkages affect behaviour and farmer strategies, so as to support those behaviours related to beneficial changes.

* The transportation system in remote flood plain areas:

- Assessment of the transportation needs for flood plain agricultural development.
- Breakdown of the transportation modes and the costs of development of those different modes to support input supplies and output marketing from flood plain agriculture.
- Analysis of how changes in the mode, availability, capacity, costs of flood plain transport affect agriculture.

* Consider comparative studies of different types of farmers and other beneficiaries' responses to flood control actions and the socio-economic and environmental implications of purposive interventions in different flood plains of the world (e.g. Mississippi, Netherlands, Nile, Mesopotamia, Indus, Orissa, Mekong, Hwangho, etc.).

* Seek out and solve priority research for attaining the NARS Goal in flood plain areas—and evolve an appropriate (Coordination System)

e.g. BARC, MPO, SPARRSO, BIDS linking national and international collaborative research and ensuring a public access data base to support policy-making and project investment. This will integrate DAE, SPARRSO and AFZ GIS systems for monitoring and forecasting the impacts of flood on productivity and incomes. The centre should design computer programmes to assist policy modelling efforts to:

- Estimate losses depending upon flood duration, timing, height and rise etc. in different agro-ecosystems.
- Design scenarios with options for Flood Plain Rehabilitation Programmes.
- Estimate the maximisation of returns under different scenarios from investment in different flood plain technologies.

CHAPTER EIGHTEEN

BIRTH OF A MEGAPROJECT: POLITICAL ECONOMY OF FLOOD CONTROL IN BANGLADESH*

James K. Boyce

Introduction

A massive flood control plan for Bangladesh, launched under the direction of the World Bank, could drastically change the nation's environment. The Bank's stated aim is to produce *"higher economic returns from land, property and infrastructure"* (World Bank 1980a). Critics of the plan fear, however, that the resulting environmental modifications will threaten the livelihood of millions of poor farmers and fishermen.

The World Bank plan sets forth an agenda of flood control investments for the next five years, leaving the specifics of the longer-term agenda for a later decision. The most dramatic long-term proposal, prepared in 1989, by a team of French engineers, calls for the construction of hundreds of miles of tall embankments along the mighty rivers of the Bangladesh delta, including the Ganges and the Brahmaputra (French Consortium 1989a). With an initial price tag of $6 billion, the French scheme would be the biggest development project in Bangladesh's history. Andrew Jenkins, a British agricultural engineer with ten years of experience in Bangladesh water control projects, terms it "*the most expensive sand castle ever imagined.'*

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The French plan has, however, powerful political backing. It was the centrepiece of the Third World development effort proposed by French President Francois Mitterand at the Group of Seven's Paris Summit Meeting in July 1989 (Economic Declaration 1989). In Bangladesh, the government of former President H.M. Ershad vigorously urged the plan upon international funding agencies, with an enthusiasm attributable in no small measure to the prospect of lucrative construction contracts for Bangladeshi firms.

The G-7 leaders and the Ershad government asked the World Bank to coordinate flood control plans for Bangladesh. At a meeting held in London in December 1989, the Bank presented its Action Plan for Flood Control to representatives of the U.S., Japanese and European governments who were asked to bankroll a major new initiative. Despite grave and well-founded reservations as to the wisdom of massive embankments, the long-term strategy envisioned in the Bank's action plan incorporated central elements of the French scheme.

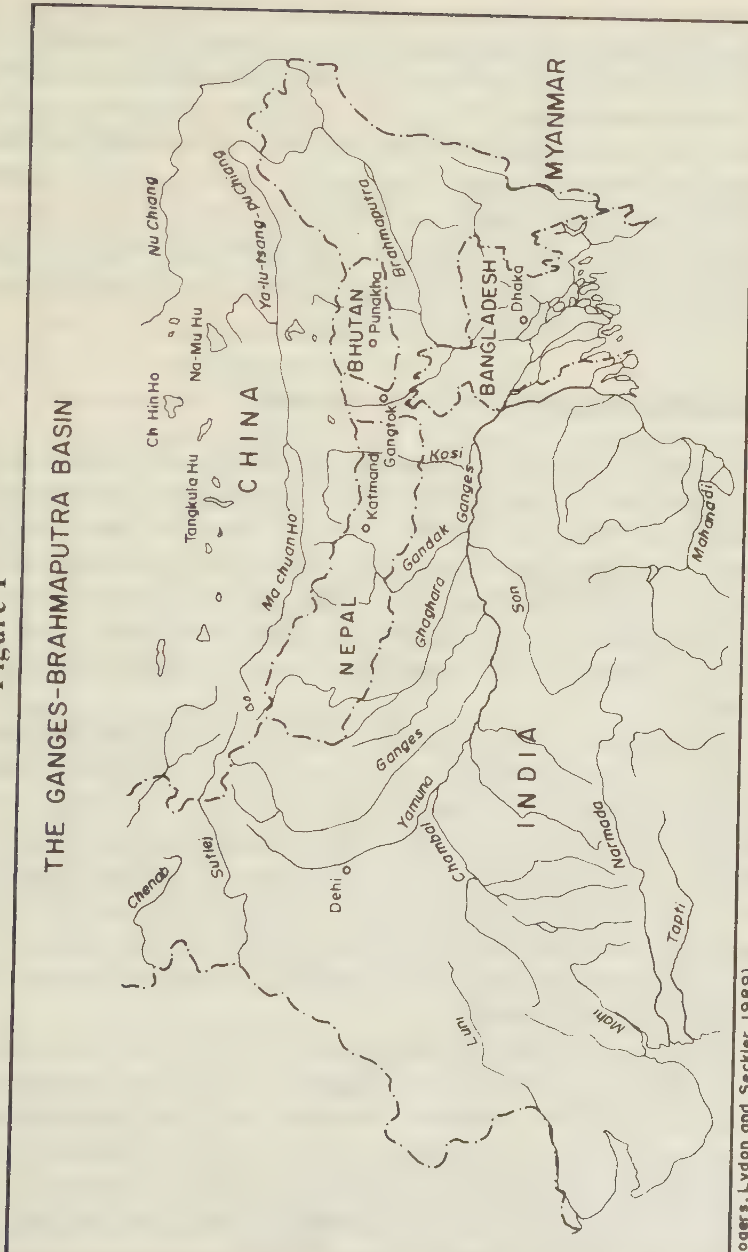
Setting

Annual floods created the vast Bengal delta over millennia, depositing sediments washed by the monsoon rains from the slopes of the Himalayan mountains. The floods also have shaped the lives and livelihood of its inhabitants. Rice, some of it grown in water so deep that the grain is harvested by boat, is the staple food of the people of Bangladesh. Fish caught in the rivers and flooded rice paddies is the main source of animal protein.

The Bengali language distinguishes between the normal beneficial floods of the rainy season, which are termed as *barsha*, and harmful floods of abnormal depth and timing, which are termed *bannya*. The English word 'flood' conflates these two very different phenomena. The *barsha*, which occurs more frequently than *bannya*, is not considered by Bangladeshi villagers to be a hazard at all, but rather a necessity and a boon for survival (Islam 1980 and Paul 1984).

During the monsoon months, in which half the countryside normally lies under water, wooden boats serve as the principal means of transport. In many places, individual houses, built on raised land, become tiny islands in a shallow sea. The melodies of the delta's folk music are drawn from the

Figure 1



(Rogers, Lydon and Seckler 1989)

rowing rhythms of the boatmen. The boat was the election symbol of the party of Sheikh Mujibur Rahman, whose sweeping 1970 electoral victory precipitated civil war in Pakistan and the birth of an independent Bangladesh.

Independence brought in its wake, a flood of a different sort: a huge influx of development assistance from foreign governments and multilateral institutions. Within two years, more than $2 billion in external resources had flowed into the country, more than it had received in its previous 24 years as East Pakistan. Since then, the influx has continued at over $1 billion per year. With the embankment project, this aid now threatens to sink the boat, or more precisely, to ground it.

The 1988 Floods: Enter the French

The annual floods which created the delta and give life to its people are fickle benefactors. Too little water can mean drought, as occurred in 1990, threatening serious crop failures. But too much water can also create hardship. In 1988, floods described by hydrologists as a once-in-a-century event (UNDP 1988 and Rogers *et al.* 1989) forced millions of peasants to abandon their homes, seeking temporary shelter on higher ground. The disruption extended to the capital, Dhaka, where two-thirds of the city was flooded.

Among those who witnessed the 1988 flood was Danielle Mitterand, wife of the French President, who visited Dhaka as a guest of former President Ershad (Powell and Shahriar 1989 and Lydon 1989). Deeply moved by the experience, Madame Mitterand described the floods to her husband upon her return to France. The French President, in search of projects to implement his vision of greatly expanded aid to the Third World, responded by sending a team of 30 French engineers to Bangladesh to study the flood problem together with the Bangladesh government engineers and to draw up a plan for its solution.

The French engineers' scheme, prepared in five months, would dramatically change the environment of Bangladesh. The country's great rivers would no longer twist across the countryside, spilling their waters and sediment onto the land. Rather they would hurtle to the sea, regimented by massive embankments. Rainwater accumulating on the lands beyond the embankments would be pumped into the canalized rivers, providing 'total flood protection'. The initial cost estimate—$6 billion in construction outlays,

plus perpetual maintenance costs of $165 million per year after completion—may err on the low side, according to experts familiar with the plan.[1]

Flood Prevention *versus* Flood Control

The primary economic rationale advanced for the project is that it will improve agricultural performance. There is undoubtedly much scope for increasing food production in Bangladesh. Despite some of the world's most fertile soils, it has the lowest per hectare rice yield of any major rice-producing country. Despite abundant water supplies, only 15-20 per cent of the cropland receives irrigation in the dry winter season. At the same time, rainy-season yields are constrained by inadequate drainage and unpredictable floods. Improved water control including drainage and dry-season irrigation as well as flood control, is widely recognized as the key to fulfilment of Bangladesh's rich agricultural potential (Boyce 1986, 1987 and Hossain 1986).

However, flood control does not necessarily mean flood prevention. Between the extremes of zero control and zero floods, lies a wide range of alternatives, which seek to maximize the beneficial effects of floods while minimizing their damages. These include the construction of ponds for surface water storage and fish culture, local improvements in drainage, submersible embankments which would check flooding only during the crucial early weeks of the rice crop and much better preparation for emergencies caused by unusually high and rapid flooding. These 'soft' measures would be far less expensive and environmentally disruptive than the high levees proposed by the French engineering team. They would also require active participation by the local population in project planning and execution.

The agricultural losses caused by floods do not justify the massive expenditures needed for 'total flood protection'. Indeed, 1988 saw bumper rice harvests in much of Bangladesh, despite the once-a-century floods, partly thanks to increased residual moisture and soil fertility in the dry winter season.[2] Rice output surpassed 15 million tons, close to the all-time record set the year before in 1987.

A review of rice output trends in the past two decades indicates that years of abnormally high floods have produced normal or above-average harvests, whereas drought years have led to serious production shortfalls. For Bangladesh's rice farmers, too little water is a greater threat than too much.

Nevertheless, measures to control the timing and depth of flooding undoubtedly could have positive agricultural impacts. In some areas, for example, flood control (as opposed to flood prevention) would permit a shift from broadcast sowing of rice to seedling transplantation, which with current technology gives higher yields. Similarly, on some lands, flood control could expand possibilities for growing more than one crop per year.

An important benefit of the annual floods, only recently recognized by soil scientists, is that the blue-green algae which thrive in the flood water play a key role in the fertility of the rice fields (Brammer 1988 and Ladha *et al.* 1985). The algae capture atmospheric nitrogen and then release this crucial nutrient in the soil for uptake by the roots of the rice plants. If this nitrogen source was eliminated by flood prevention, very large quantities of chemical fertilizers would be required to offset the loss.

The role of silt carried by flood water in maintaining soil fertility remains poorly understood, underscoring the need for much more scientific research before drastic interventions are contemplated.

The environmental impact of embankments on inland fishing is also a cause for serious concern. One-third of Bangladesh's total fish catch comes from flooded lands and another third from inland rivers and estuaries, where many species use the flooded fields as spawning grounds (Minkin 1989 and Rogers *et al.* 1989) These open water fisheries are, particularly, important to the rural poor, whose income and subsistence depend heavily upon free public access to surface waters and their aquatic life.

Very little is known about the potential impact of large-scale embankments upon the ecological balance which underpins this industry. But past experience with smaller embankments in Bangladesh provides alarming precedents. An independent group of Bangladeshi scholars, convened in November 1989 by the Bangladesh Agricultural Research Council, noted that the traditional diversity of Bangladesh's aquaculture resources *"has already been drastically reduced by embankments, and that past projects have left scores of fishing villages in decay."*[3]

Embankments: Some Technical Problems

The Bangladesh embankment scheme presents extraordinary risks and technical problems. *"The costs of embanking and stabilizing those*

rivers would be enormous," says Fred Bayley, who supervises the largest river embankments in the Western hemisphere, as Chief Engineer for the U.S. Army Corps of Engineers in the lower Mississippi district.

The peak flow of the Ganges-Brahmaputra confluence in the Bengal delta is more than double that of the lower Mississippi. The rivers carry sediment loads of more than two billion tons each year, six times the volume carried by the Mississippi (Encyclopedia Britannica 1990). If sediments were to accumulate in the confined river beds, this would necessitate massive annual dredging operations or the construction of higher and higher embankments. The French plan envisages embankments up to 25 feet in height. *"When a five-foot levee is breached, you've got a problem,"* says Bayley. *"When a twenty-five foot levee is breached, you've got a disaster"* (Personal communication).

The French feasibility study notes that maintenance of existing embankments in Bangladesh has been "*badly neglected.*" Repairs are typically delayed until *"the situation has already become critical."* This policy would not "*be viable any more*" under the proposed project, the French study continues, since an "*unexpected failure*" of embankments would expose people living in protected areas to sudden floods of catastrophic proportions. Yet the study concedes that the capacity of the Bangladesh government to finance regular levee maintenance "*remains an important question*" (French Consortium 1989a).

The Bangladesh embankments would be constructed in one of the world's most earthquake-prone locations. An active fault line lies along the northern edge of the delta, at the foothills of the Himalayas. The largest earthquake on land known to seismologists, registering 9.0 on the Richter scale, occurred in this region in 1897. Witnesses reported that the quake caused great plumes of water to gush from the ground. A century earlier, an earthquake caused major shifts in the courses of the Brahmaputra and Teesta rivers in north-western Bangladesh.

Remarkably, the feasibility study drawn up by the French team addresses this risk simply by recommending that *"special steps"* be taken to compact *"the first 12 to 15 metres of the embankment foundations"* in the upstream reaches of the project (French Consortium 1989). The glossy summary version of the study, distributed to political leaders and the public, does not mention earthquakes (French Consortium 1989).

The World Bank's Action Plan

The World Bank's action plan, unveiled at the December 1989 meeting, calls in the short-term, for pilot programmes, flood protection for Dhaka and further studies. It also emphasizes possibilities for controlled flooding, that is, engineering works to reduce flood damages without eliminating beneficial effects of flooding.

The Bank's plan represents a compromise among different proposals advanced in four recent reports commissioned respectively by the French, the United States and Japanese governments and the United Nations Development Programme (UNDP). At one end of the spectrum is the French proposal discussed above; at the other, is the U.S. commissioned 'Eastern Waters Study,' which advocates actions to help people 'live with the floods,' coupled with continued emphasis upon dry-season irrigation (Rogers *et al.* 1989). The Japanese, whose potential financial role gives them considerable influence, are also reportedly skeptical about the French plan. The UNDP report occupies the middle ground (Powell and Shahriar 1989 and Bingham 1989).

The government of former President H.M. Ershad was reportedly 'infuriated' by the 'defeatist tone' of the U.S. report (Powell and Shahriar 1989). This reflects the Ershad government's fear of any threat to prospects for funding the multi-billion dollar embankment scheme; as *Newsweek* put it, *~the government naturally prefers the bold French approach"* (Powell and Shahriar 1989). The title of the U.S. report also made it an easy target for the exploitation of nationalist resentment. The waters of the Ganges and the Brahmaputra are not 'eastern' from the standpoint of Bangladesh, but rather from the standpoint of neighbouring India, with which Bangladesh has long been engaged in disputes over water-sharing and the augmentation of dry-season flows (Crow 1981, Kaye 1989 and Crow and Lindquist 1990) In the face of the Bangladesh government's hostility, the U.S. ambassador in Dhaka and other U.S. officials sought to distance themselves from the report. Its authors were pointedly not invited to the London meeting.

The UNDP report, prepared jointly with the Government of Bangladesh, proposes large-scale flood control works but is more cautious than the French plan: *"Although for the long-term, the strategy 'flooding prevented' is probably the guiding model for flood protection, for the medium-term, the*

strategy 'flooding controlled' may offer the most feasible framework for a workable flood protection programme" (UNDP 1988). The UNDP report notes that controlled flooding offers several advantages over total flood prevention. It would allow replenishment of surface and underground water reserves, improved conditions for fisheries and continued internal navigation. Given these advantages, it is curious that the report nevertheless endorses a long-term model of 'flooding prevented.'

The World Bank's action plan adopts a similar stance. For the long-term, it *"envisages that the Brahmaputra and the Ganges may eventually be embanked on both sides, possibly followed by the Padma and Meghna rivers,"* an apparent (albeit not unambiguous) endorsement of the central element of the French plan (World Bank 1989a).

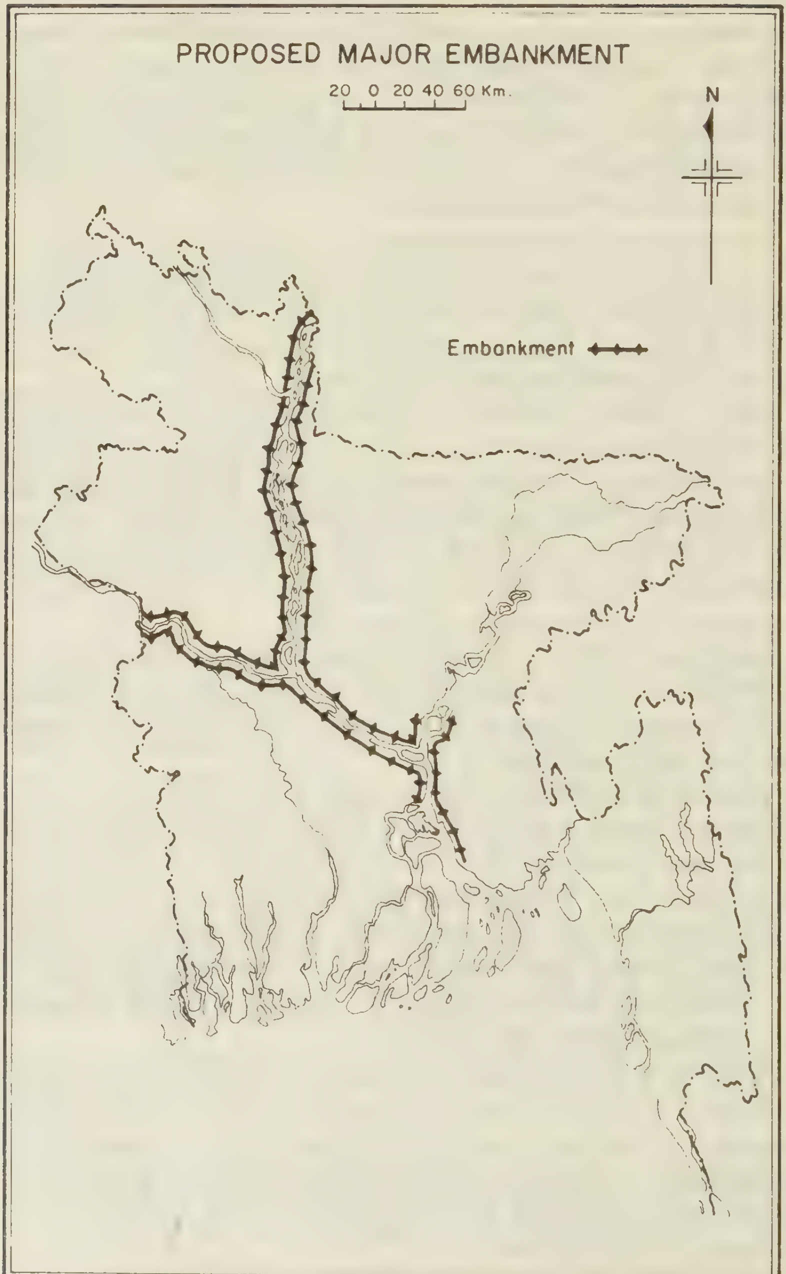
Experts involved in the formulation of the Bank's plan stress its research component: *~At this point in time, we feel that insufficient is known either to rubbish the idea of a major structural solution to the flood problem (e.g. the French and UNDP reports) or of concentrating primarily on a non-structural strategy (the Eastern Waters Study)."* The Action Plan is designed to get the extra information that is needed to come to a decision about the potential and scope of future flood control works.

Few question the need for further research on the technical, environmental and economic questions involved in flood control in Bangladesh. Critics fear, however, that the Action Plan advances an agenda in which certain answers are favoured over others.

The Bank plan attempts to be 'all things to all people,' according to a consultant involved in its formulation. The inclusion of a number of 'soft' options wins favour from critics of the 'hard' approach proposed by the French team. But at the same time, the Action Plan can be interpreted as a first step towards large-scale embankments. This possibility is deliberately left open in order to placate proponents of the 'hard' approach within the Bangladesh and French governments. *"No one wants to say that the emperor has no clothes."* explains the consultant.[4]

Hence, the Bank's plan states, *"Future development of the flood plains of Bangladesh demands that, eventually, the river courses should be stabilized rather than be left free to change their geometry"* (World Bank 1989a). Although perhaps motivated simply by the diplomatic exigencies of the moment, such declarations may open the door to large-scale engineering adventurism in coming years.

Figure 2



(World Bank 1989b)

In a policy brief issued by the Bangladesh Agricultural Research Council on the eve of the London meeting, a group of senior Bangladeshi scientists charged that the concept of 'staged developments' espoused in the World Bank action plan was *"inadequate for coping with potential flaws in embankment centred schemes"* (BARC 1989).

The World Bank's action plan specifically allocates only $200,000 for environmental impact assessments. In addition, proposed regional and project feasibility studies will include unspecified environmental components. Peter Rogers, a Harvard University professor of environmental engineering who co-authored the *'Eastern Waters Study'* and has been involved in water planning in the region since the mid-1960s, charges that the aim is *"to moderate embankment effects, rather than to affect the decision to construct or not to construct an embankment."* In this respect, he maintains, environmental considerations have been *"marginalized from the outset"* (Personal Communication).

Concluding Remarks: Flood Control and Democracy in Bangladesh

Over the centuries, the cultivators and fisherfolk of the Bengal delta have learned to survive in a setting in which the boundary between land and water is elusive and ever-changing. Their accomplishment should not be romanticized. Millions of Bangladeshis today live near the edge of subsistence, while agricultural potential remains unfulfilled. But neither should it be underestimated.

Indigenous adjustments to floods include the building of homes on natural levees and raised platforms, the planting of different rice varieties at different levels of the flood plain, the development of 'floating' rice varieties that can grow by more than 6 inches in a 24-hour period with rising flood levels and the use of bamboo stakes and fences to support and protect rice crops (Rashid and Paul 1984).

This resourcefulness stands in marked contrast to the local populace's response to top-down initiatives of the Bangladesh government and its international patrons. Remarking upon the endemic problem of sub-standard maintenance of embankments built under past government schemes, the UNDP report decries *"the total disinterest often demonstrated by the*

population to maintain the structures and works that are to protect their life and property. Unless this situation is changed fundamentally," the report continues, *"to the extent that people respect flood protection infrastructure and are willing to contribute to proper maintenance, the very purpose of building embankments and structures will be defeated"* (UNDP 1988).

Analogous problems have plagued past irrigation development efforts in Bangladesh. Marked inequalities in the country's land ownership pattern have not only biased the distributional outcomes of government interventions in favour of the rural rich, but also have posed a formidable barrier to the local cooperation essential for water control development (Boyce 1987). In response, the government and international agencies pursued a strategy of subsidized private irrigation development, channelling pumps and wells to large farmers. There are indications, however, that this strategy is reaching its limits, as the opportunities for non-cooperative irrigation are depleted.[5]

Engineering can and must play a crucial role in addressing the water control constraint upon Bangladesh's agriculture. But while necessary, engineering alone is not sufficient. First, there is a need for much more scientific research into the ecological complexities of the delta. And second, there is a need for the mobilization of the cultivators and fisherfolk who best know the terrain and upon whose active involvement, the success or failure of water control initiatives will ultimately hinge.

Foreign engineers and their westernized Bangladeshi counterparts often bring to this environment a very different ideal landscape, one in which land is dry and rivers are tame. Confronted by the delta, their impulse is not to learn from nature but to transform it.

French President Mitterand expressed this vision of progress in his September 1988 address to the United Nations General Assembly: *"Development is achieved via the launching of major projects of world interest, which are capable of mobilizing energy to help such and such a region wounded by Nature, for example, stabilizing the rivers which flood Bangladesh. France, for its part, is ready to contribute"* (French Consortium 1986).

So far, the supposed beneficiaries of flood control in Bangladesh—the country's poor majority—have been virtually excluded from the decision-making process. The World Bank Action Plan concedes that past embankment projects have been undermined by deliberate cutting of embankments by disgruntled farmers and fishermen and hence calls for

"closer involvement of the beneficiaries" and *"more cooperation among farmers"* (World Bank 1989a). It provides no inkling, however, of how these are to be achieved in a context of military rule *(upto 1990)* and a highly inequitable land ownership pattern.

Noting that *"democratic accountability requires public opinion first of all to be educated"*, M.M. Rahman, executive vice chairman of the Bangladesh Agricultural Research Council, states that the Bangladeshi public *"has the incontrovertible right to know about the costs and benefits of proposed flood control investments"* (BARC 1989). But democratic accountability has not been a prominent feature of development planning in Bangladesh.[6]

In coming months and years, officials of the international agencies and the Bangladesh government will further consider how to treat the 'wounds of nature' in the delta, erecting a long-term strategy upon the foundation of the current Five-Year plan. In the end, the good intentions, technological hubris and political opportunism driving the embankment scheme may be tempered by economic and environmental objections. The cultivators and fisherfolk who have lived with the rivers for generations, are likely, however, to be notably unrepresented in the deliberations.

Notes

[1]French Engineering Consortium and Bangladesh Water Development Board (1989, p. 1-45). This estimate refers to one of four options advanced by the French team; 'distant' embankments with manual construction. Initial price tags on the other three options ranged from \$5.3 to \$10.2 billion, with annual maintenance costs of \$155 to \$180 million.

[2](Rogers, Lydon and Seckler 1989, p. 5). Indeed, the (World Bank 1989a, p. 15) reports that better-than-expected *aman* (monsoon season) and record *boro* (winter season) rice harvests, coupled with large-scale government imports in response to the floods, led to a food grain glut in Bangladesh in early 1989: *"Boro procurement had to be suspended because of the lack of storage capacity. Market prices fell by as much as 25 per cent below the procurement price, adversely affecting incentives to farmers."*

[3](Bangladesh Agricultural Research Council 1989, p. 4). Similarly, (Minkin 1989, p. 8) reports, *"Nearly total loss of open water fisheries has been documented in some flood control projects."*

[4]Telephone interview (anonymity requested), 26 November 1989. Similarly, (Lydon 1989) offered this prediction: *"Some donor-country representatives attending the London meeting will try to restrain the Bangladeshi engineers' response to floods. But the diplomats will not oppose embankments so strongly as to compromise their countries' future participation in this decision-making or to complicate relations with Bangladesh."*

[5](The World Bank 1990, pp. 96-98) reports that the beneficiaries of the government's minor irrigation programmes, *"were essentially the large farmers."* The Bank cites *"difficulties in group formation of small farmers"* as a reason for declining sales of minor irrigation equipment since 1985 and observes that fragmentation of landholdings will *"put a major management constraint on further expansion of minor irrigation."*

[6]As if to underscore this reality, Rahman was dismissed from his post after making this statement.

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CHAPTER NINETEEN

ENVIRONMENTAL ASPECTS OF THE BANGLADESH FLOOD ACTION PLAN*

Barry D. Clayton

The Land of Plenty

Bangladesh is a country of some 145,000 square kilometres, 80 per cent of which occupies the delta of the Ganges, Brahmaputra, Meghna and various other small rivers. Two major elements dominate development in Bangladesh: people and water, both of which are present in abundance. Since 1961, the population doubled to 110 million in 1989 and is expected to double again by 2020. More than three quarters of the population live in the rural areas of the delta flood plains where they are dependent on agriculture and fishing.

Seasonal flooding is normal in Bangladesh and farmers' cropping practices are well adapted to differences in both the depth and duration of seasonal flooding on the different types of land on their fragmented holdings. However, whenever water levels rise earlier, later, higher or more rapidly than expected by farmers, then the floods are often disastrous with not only crop damage but also loss of life and human misery.

These abnormal inundations of the flood plains are caused by flash floods, river floods and rain water floods. In addition, periodic storm-surge floods resulting from tropical cyclones also strike the coastal areas. The nature of these different types of flood and the damage they cause has been reviewed by (Hugh Brammer 1990a). The most recent floods to capture the

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attention of the world's media were in 1987 and 1988 and were reported to be the worst on record. But Bangladesh is known to have suffered catastrophic large-scale natural disasters throughout this century and before (Brammer 1990a and Hossain *et al.* 1987).

The social and economic consequences are extremely serious for the country. Periodic large-scale losses in agricultural production and the need to divert development funds for relief and rehabilitation purposes and for purchasing replacement food, constantly conspire to undermine the nation's economy.

Food production, particularly, of staple rice, must be expanded to meet the needs of the large and rapidly growing population. Rice is grown throughout the year: two crops—*aus* and *aman* are grown under rainfed and flooded conditions in the wet *kharif* season between May and September; the other *boro* is mainly produced by irrigation in the dry *rabi* season between October and April. One of the main potentials for expanded production is dry season irrigation.

Success has already been achieved in recent years in promoting small-scale irrigation, largely based on tubewells and lowlift pumps drawn from surface waters. To meet the country's food security requirements, the government's policy is to continue to promote investment in irrigation to increase agricultural production, using high-yielding varieties combined with fertilisers and pesticides. In order to protect not only the lives and property of the rural population, but also the infrastructural investment needed for increased irrigation and agricultural production, it is widely accepted that something has to be done to mitigate the devastating effects of the floods.

International Attention to the Flood Problem

The disastrous 1987 and 1988 floods stimulated considerable international interest in helping Bangladesh find a solution to the flood disaster problem. Joint studies were undertaken by the government of Bangladesh with UNDP (UNDP 1989) and with the French (French Engineering Consortium 1989). Separate studies were also carried out by USAID (Rogers *et al.* 1989) and the Japanese (Japanese Flood Control Experts 1989).

The UNDP study recommended a National Flood Master Plan involving embankments along the major rivers and controlled flooding of adjoining flood plain areas with large embanked compartments (polders).

The USAID Eastern Waters Study was against the construction of extensive channel embankments on the grounds of expense and possible environmental risks and suggested alternative efforts towards minimising flood vulnerability, improving emergency planning and relief services, flood warning, modest embankments and flood proofing measures.

A departure from the large polder concept was suggested by the French report which presented a very expensive long-term programme in successive five-year plans. Amongst other features, it proposed longitudinal embankments along the major rivers and tributaries with some river training.

The Japanese report cautioned against long and continuous river embankments without further careful technical feasibility and economic viability studies and recommended a staged programme of physical works, including embankments in limited areas, in combination with existing or planned road embankments and the provision of cellular series of polders. Other non-structural measures such as flood forecasting, warning and flood fighting were also included.

In July 1989, major donors at the G7* Summit called for effective, coordinated action by the international community to support Bangladesh and welcomed the agreement of the World Bank to coordinate the international efforts. The World Bank subsequently chaired an international conference in London in December 1989 at which it presented an Action Plan for Flood Control in Bangladesh (World Bank 1989)—now referred to as the Flood Action Plan (FAP). This Action Plan represents a compromise between interventionist and non-interventionist lobbies within Bangladesh. There is a strong engineering lobby in Bangladesh, with high-level political support, for a priority programme to embank the full length of the country's major rivers so as to convey the flood flow entering the country safely through to the Bay of Bengal (Brammer 1990b). On the other hand; agricultural, fisheries, conservation and other interests are generally against large-scale water control infrastructure. The Action Plan makes recommendations which mediate between these two positions and draws elements from the proposals of the four major studies mentioned above. The team which prepared the Action Plan comprised some of the best available indigenous

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*The group of seven most industrialised nations: Japan, Germany, France, Canada, United States of America, Britain and Italy.

and international expertise on the flood problem in Bangladesh, many of whom had also been involved in the other studies.

Elements of the Action Plan

The five-year (1990-1995) Action Plan, which was endorsed by the 1989 London conference, follows a staged approach. In the first years, it concentrates on regional studies of flood control and drainage potentials and supporting activities in order to identify feasible projects for implementation later in the Plan (and in subsequent Action Plans). It also focuses on flood control from the Brahmaputra and Ganges. The downstream problems of the Padma and Lower Meghna will be deferred until the effects on river morphology of upstream embankments are evaluated. The Plan has 11 main components and 15 supporting activities (See Table 1). The implementation schedule is shown in Table 2 and the location of the main activities in Figure 1. The cost of implementing these activities is estimated at US $146.3 million. It is envisaged that they could eventually lead to a pipeline of projects costing about $500 million (Brammer 1990b).

Environmental Issues and Impacts

The separate studies on which the Action Plan is based address, in rather general terms, the potential environmental impacts that might be anticipated. The Action Plan document itself, however, deals with the issues in a dispersed and superficial manner. The reader would need to have access to the previous studies to appreciate some of the problems involved. The proposal for a supporting environmental study (component 16) merely states that the plan *"could have adverse impacts on soil productivity, fisheries, ground-water recharge, health and wildlife"*. During the period since the 1989 London conference, the on-going procedures for implementing the Action Plan have, admittedly, given consideration to the environmental issues. Terms of reference for component 16 (funded by USAID) provide, *inter alia*, for studies of some special environmental problems and the preparation of guidelines for environmental impact assessment.

The Action Plan and previous studies are agreed that many of the possible impacts are unclear. This is partly because of the lack of or inadequacy of baseline environmental data and partly because there is little or no previous experience of the impact of the type of proposals which are

made in the Action Plan in an active delta situation. It is precisely due to these deficiencies, that the plan adopts a staged approach in which various further studies and pilot projects are to precede the construction of major plan components (Table 1). Furthermore, the plan sensibly proposes that pilot projects be undertaken in upstream locations since any unpredicted adverse effects of contained rivers (e.g., higher flow velocities and water levels, increased flow, increased sediment transport and bank erosion, all leading to greater downstream floods) should become clear.

Table 1

Components and Supporting Activities of the Action Plan

PLAN COMPONENTS

Brahmaputra Right Bank

a. Strengthening of the right embankment.

b. North-west regional drainage study to examine various drainage proposals.

c. Improved flood control and drainage through preparation of projects for a diversion drain and an interceptor drain (subject to confirmation by (b).

Brahmaputra Left Bank

a. North Central regional flood control drainage study to examine various alternatives and make recommendations for future water control development.

b. Feasibility studies for Brahmaputra Left (BL) Embankment and BL compartment (50,000 ha) (both contingent on results of (a) but already assumed as probable outcomes.

Ganges Right Bank, Padma and Lower Meghna

a. South-west regional flood and drainage study including the Sunderban forest reserve, to consolidate and integrate previous studies and plans and to formulate priority projects.

b. Feasibility studies for Gorai Head offtake from Ganges (providing fresh water to south-west to counter-act saline water intrusion) and preparation of project for SW and SC drainage improvement (both assumed as likely priority projects).

Meghna Left Bank

a. South-east regional study to examine hydrology problems and river morphology (taking into account various on-going activities) and to identify/formulate projects for implementation.

b. Preparation of two projects (already identified as probable priority projects: Gumti FCDI (Flood Control Drainage and Irrigation) project; and SE drainage project.

North-East Region

a. North-east regional study to address problems of flash floods in the area, hydrological and topographical data needs, methods for flood mitigation and to evaluate existing schemes leading to a regional water management programme.

b. Preparation and construction of a flood protection rehabilitation project and other (to be identified) projects.

Cyclone Protection

Rehabilitation and construction of new coastal embankments.

Urban Areas

Flood protection and drainage works for Greater Dhaka and other towns.

Flood Forecasting, Warning and Preparedness

Strengthening and integrating existing and starting new programmes.

SUPPORTING ACTIVITIES

Studies

To address crucial issues common to most of the regions, designated to provide criteria needed for social, economic, environmental, operation and maintenance and management aspects that will be covered in the regional studies and in project preparation.

Pilot Projects

To test concepts and improved technology in compartmentalisation, bank protection, river training, fisheries and flood proofing.

Data Collection and Analysis

Including mapping, satellite imagery, geographical information systems, river survey programmes and flood management modelling.

Institutional Development

A programme to strengthen government capacity to implement the plan and to ensure beneficiary participation.

There are, however, numerous examples of large infrastructural projects around the world which have proceeded without an environmental impact assessment (EIA) and with unforeseen and sometimes, serious consequences, such as the Victoria Dam in Sri Lanka and the Brokopondo Lae Dam in Surinam. Despite the proposed staged approach described above, the Action Plan document suggests that preparation of plans and preliminary design of many of the envisaged physical infrastructure projects will be undertaken at the same time as the various environmental and resource studies. The implementation of such projects is intended to be dependent on the results and conclusions of the supporting studies. Yet, the project planning and

Table 2

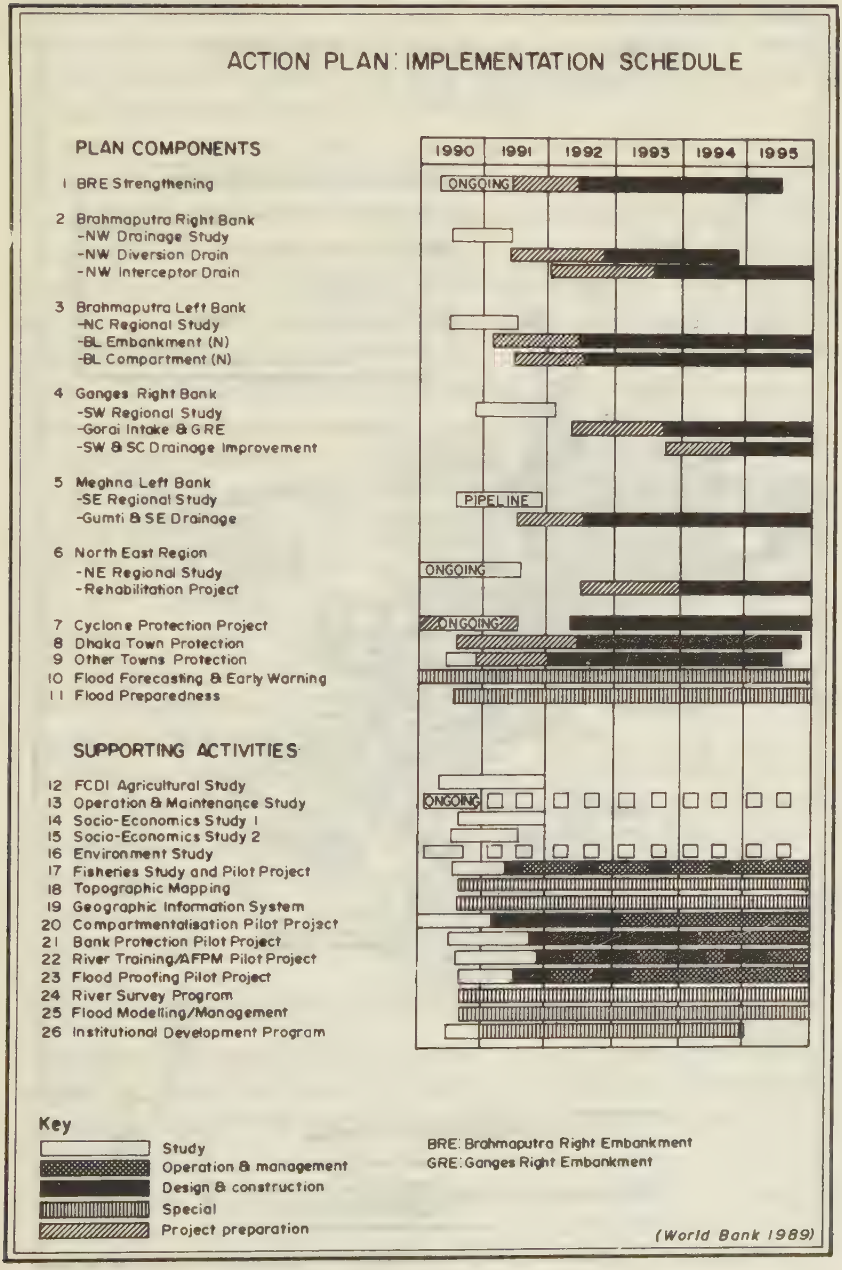
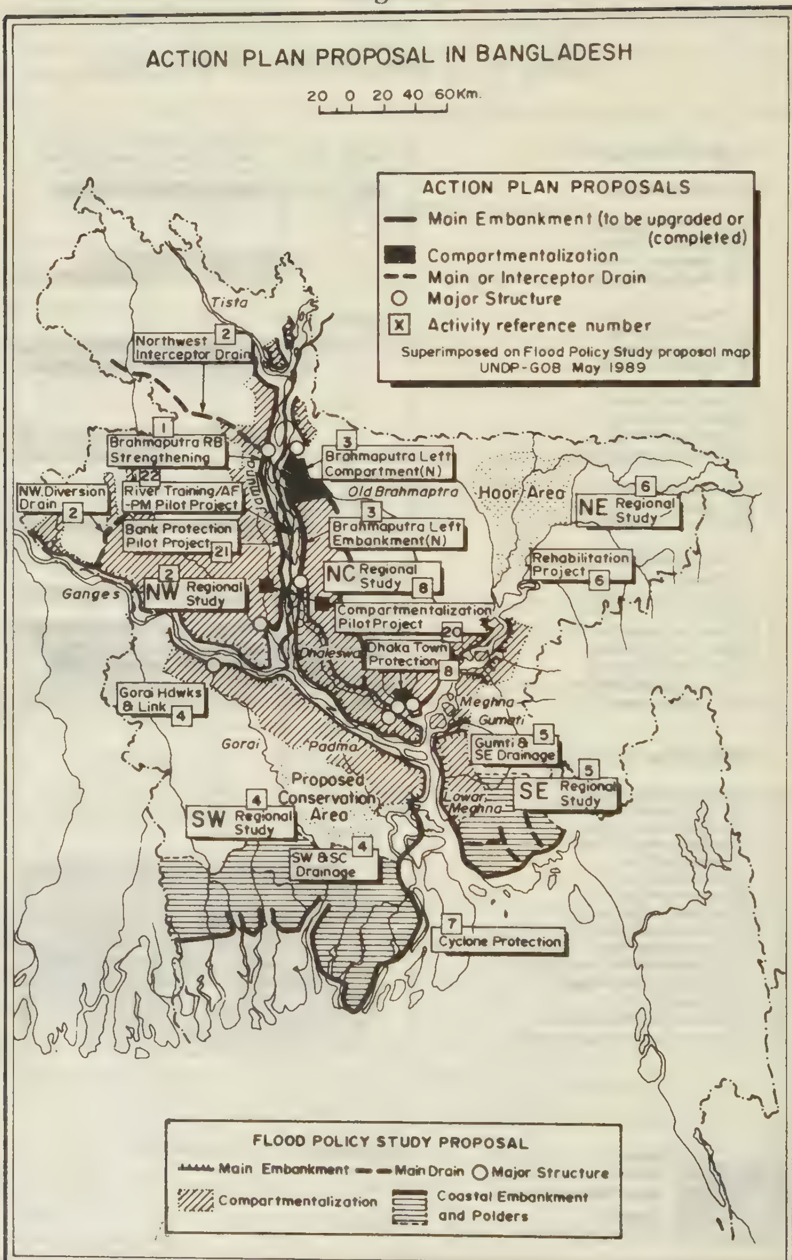

ACTION PLAN: IMPLEMENTATION SCHEDULE
PLAN COMPONENTS
1990
1991
1992
1993
1994
1995
1 BRE Strengthening
2 Brahmaputra Right Bank
-NW Drainage Study
-NW Diversion Drain
-NW Interceptor Drain
3 Brahmaputra Left Bank
-NC Regional Study
-BL Embankment (N)
-BL Compartment (N)
4 Ganges Right Bank
-SW Regional Study
-Gorai Intake & GRE
-SW & SC Drainage Improvement
5 Meghna Left Bank
-SE Regional Study
-Gumti & SE Drainage
6 North East Region
-NE Regional Study
-Rehabilitation Project
7 Cyclone Protection Project
8 Dhaka Town Protection
9 Other Towns Protection
10 Flood Forecasting & Early Warning
11 Flood Preparedness
SUPPORTING ACTIVITIES
12 FCDI Agricultural Study
13 Operation & Maintenance Study
14 Socio-Economics Study 1
15 Socio-Economics Study 2
16 Environment Study
17 Fisheries Study and Pilot Project
18 Topographic Mapping
19 Geographic Information System
20 Compartmentalisation Pilot Project
21 Bank Protection Pilot Project
22 River Training/AFPM Pilot Project
23 Flood Proofing Pilot Project
24 River Survey Program
25 Flood Modelling/Management
26 Institutional Development Program
ONGOING
PIPELINE
Key
Study
Operation & management
Design & construction
Special
Project preparation
BRE: Brahmaputra Right Embankment
GRE: Ganges Right Embankment
(World Bank 1989)

Figure 1


ACTION PLAN PROPOSAL IN BANGLADESH
20 0 20 40 60Km.
ACTION PLAN PROPOSALS
Main Embankment (to be upgraded or (completed)
Compartmentalization
Main or Interceptor Drain
Major Structure
Activity reference number
Superimposed on Flood Policy Study proposal map UNDP-GOB May 1989
Tista
Northwest Interceptor Drain 2
1 Brahmaputra RB Strengthening
22 River Training/AF-PM Pilot Project
NW Diversion Drain 2
Bank Protection Pilot Project 21
3 Brahmaputra Left Compartment(N)
Old Brahmaptra
Hoor Area
6 NE Regional Study
3 Brahmaputra Left Embankment(N)
Rehabilitation Project 6
NC Regional Study 8
2 NW Regional Study
Ganges
Jamuna
Compartmentalization Pilot Project 20
Dhaleswari
Dhaka Town Protection 8
Gorai Hdwks & Link 4
Meghna
Gumti
Gumti & SE Drainage 5
5 SE Regional Study
Gorai
Padma
Proposed Conservation Area
Lower Meghna
4 SW Regional Study
4 SW & SC Drainage
7 Cyclone Protection
FLOOD POLICY STUDY PROPOSAL
Main Embankment
Main Drain
Major Structure
Compartmentalization
Coastal Embankment and Polders

design effort is likely to generate considerable momentum and will involve large financial investment. In these circumstances, there is a real danger that the results of the studies, especially where significant adverse environmental or social impacts are identified, will be unable significantly to influence or change project implementation.

Apart from the environment support study itself (component 16), environmental issues are significant in the agricultural study (component 12), the two socio-economic studies (components 14 and 15) and the riverine/fisheries study (component 17). Many of the environmental and socio-environmental issues that need to be considered and investigated in these separate studies overlap considerably. The opportunity to integrate these into a single multidisciplinary programme has been missed. Although suggestions to this effect were made at the December 1989 London conference, the various studies are now being undertaken separately and with potential for overlap and duplication.

Environmental issues also need to be considered during the various regional studies which are part of the main plan components (See Table 1). The original concept was that the environmental support study should *inter alia*, provide guidelines on EIA procedures to be used in the regional and other feasibility studies. Unfortunately, at the time of writing (June 1990), work on some of the regional studies has already commenced whilst the environmental support study has been delayed. Draft EIA guidelines will hopefully be available by the end of 1990.*

The main purpose of the Action Plan is to control flooding but it is meant to have many other positive impacts. There can be less certainty regarding the negative impacts, mainly (as previously mentioned) due to the lack of baseline data. Some of these are discussed. Sea-level rise as a result of climate change could aggravate inland flooding in Bangladesh by raising river base-levels. The issue is not considered in this paper.

Environmental Impact Assessment

The delta flood plains of Bangladesh are extremely dynamic and subject to sudden and violent changes. The mouth of the Ganges has migrated some 250 km. eastward in the last 200 years (Deam and Treygo 1989). There are

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*Editor's Note. The EIA guidelines are now available. However, its contents are controversial.

also distinct ecological and physical rhythms in all flood plains. There are those which occur over a period of one year from one flood season to the next and others, which have much longer time scales (e.g., exceptional floods with a 1000 year return period). Studies of the environmental impact of the major developments proposed in the Action Plan are likely to require considerable time to yield meaningful results. Whilst ideal EIA studies lasting several years may be politically unacceptable, more rapid studies of less than one year are unlikely to be of great value. The regional studies and supporting studies are mostly scheduled to be completed in about one year (See Table 2), which will allow barely time for field observations over one annual cycle.

The supporting environmental study (component 16) is charged with developing an EIA programme, identifying environmental issues and preparing EIA guidelines (for regional and other studies) which are to be undertaken *"as and when required to qualify other studies"*. All structural proposals in the plan are likely to need an EIA but these are not specifically indicated and are not adequately built into the time frame for their implementation.

Embankments

It is generally accepted that no guarantees can be given that embankments will not fail suddenly. Such breaches would cause unexpected flooding with serious consequences. It can be argued that sedimentation within confined river channels will result in river beds rising above the surrounding flood plains and that breaches will, therefore, be more dangerous. Such river bed rise has occurred in the Mississippi River in the USA and in the Yangtze and Yellow Rivers in China. The Action Plan states that the compartments and planned drainage works will be designed to contain flooding resulting from breaches or relieve it by onward distribution, thus reducing the possible local impact.

The immense power of the water scours the river beds and erodes embankments making 'river training' (the stabilisation and constraining of river courses) very difficult. It is reported that flood waters have dug 53 metres into the bed of the Meghna River, 32 metres into the beds of the Brahmaputra and Ganges and 45 metres into the Padma River (Bingham 1989). The Action Plan envisages an extensive programme of river training but sensibly proposes first to undertake trials in the northern reaches of the Brahmaputra (component 22). However, it is difficult to be optimistic that

man-made interventions will be able to effectively constrain the powerful and highly mobile rivers of Bangladesh.

Population pressure and limited availability of land means that many embankments are occupied by landless squatters. A further problem of embankment security arises from the habit of squatters digging into them to build semi-sunken houses. Public breaches of embankments are sometimes made either to reduce water levels or to admit needed water, where levels differ on opposing sides. Vigorous arguments, sometimes ending in deaths, are not uncommon between people, guarding or wishing to cut sections of the embankment. There are always loosers and winners when embankments are built and their complex social impacts must be thoroughly considered.

The seasonal floods provide an annual deposit of sediment on the land which is perceived as essential for the maintenance of soil fertility. Embankments will restrict annual sediment deposits, though their contribution to soil fertility may actually be limited, since the sediments have a low content of probable insoluble nutrients. In fact, in Bangladesh, there is often a loss of land quality due to flood deposits of sand and silt. The main fertility benefit of the floods apparently are produced by nitrogen-supplying algae living in water (World Bank 1989).

One of the benefits of the seasonal floods is the recharge of ground water lowered by dry season abstraction. Although the construction of compartments is intended to allow 'controlled' flooding (the release of a limited flow of water through regulators in embankments to allow flooding to the 'normal' levels with which farmers are familiar), there is some concern that ground water recharge will be inadequate. There is a fear that this will compound the problem of water tables already lowered due to excessive abstraction for dry season irrigation. There is already some evidence of dry season water table draw-down around tubewells in some areas affecting the viability of drinking water wells. The recent decision of the Bangladesh government to deregulate abstraction controls is likely to exacerbate the problem, as will any expansion or acceleration of the tubewell construction programme resulting from the Action Plan. But, the perceived problem of inadequate ground water recharge may not arise since recharge is almost completely effected early in the rainy season from direct rainwater flooding. Embankments along the major rivers and enclosing compartments may trap rainfall which would otherwise have drained away and cause aggravated flooding within the compartments. They may also trap standing water which

would lead to an increase in malaria and other diseases and possibly contamination by sewage and industrial wastes, etc.

Agricultural and Industrial Pollution

It is intended that the protection (and therefore security) provided by the proposed embankments and compartments will lead to increased agricultural production and industrial activity. It is stated that *boro* crop yields will be increased by an expansion of dry season irrigation, the use of high-yielding varieties and increased inputs of fertilisers and pesticides. Some people argue that the major production increases are more likely to come from improvements to the *aman* crop. Recent agronomic surveys in Bangladesh indicate that irrigating farmers apply more than twice as much fertiliser and pesticide, mainly insecticide, as non-irrigating farmers (BADC 1989). This suggests that increased dry season irrigation will create a potential hazard to surface and ground waters, through losses of nitrate and pesticide residues. It has also been argued that the expansion in dry season irrigation that has already occurred will continue on an accelerated basis with or without the Action Plan. There is virtually no monitoring at present of the use of pesticides after the point of import; distribution and sale is carried out by the private sector. Furthermore, no one knows what actual effects compartmentalisation will have on the accumulation of nitrates and pesticides. There is as yet, no published information on the exchanges of added agrochemicals between the soil and flood waters.

Most of the existing industries discharge their wastes untreated into the rivers. The main polluters are the tanneries, paper and pulp, fertiliser, pharmaceutical, sugar, jute, textile and petrochemical industries. Tanneries, for example, are a well known pollution source of very toxic heavy metals. Once again, the major problem is the lack of reliable data and the negligible amount of monitoring of pollution levels in Bangladesh (Huq and Rahman).

The effects of increased agricultural and industrial pollution need to be seriously considered. It could be that the Action Plan will result in a serious future pollution problem, with surface and ground waters being seriously contaminated. There is an obvious need for a baseline study of the existing use of pesticides and fertilizers and of existing levels of pollution.

It is understood that the environmental study (component 16) will now consider the issue of water quality in protected areas. In addition, a permanent and effective monitoring facility needs to be established. The

Action Plan makes no provision for these needs. It can be argued that this is beyond its limit, but unless the Action Plan identifies the importance of the monitoring problem, there has to remain doubt that it will be addressed.

Wetlands and Wildlife

Because of its deltaic location, Bangladesh has an extensive system of wetlands. Apart from the permanent rivers and streams, these include estuaries and mangrove swamps, shallow lakes and marshes. Some of these wetlands support an abundant variety of wildlife including rich fish fauna in the rivers (many commercially important), prawns and shrimps in estuaries, many reptiles (including 25 species of turtles and tortoises) and about 150 species of waterfowl-some of which are rare in Bangladesh (Green 1989). The wetland resources are of great economic importance to local people and to Bangladesh as a whole, and over 5 million people are dependent on fishing for their livelihood.

The potential impacts of the Action Plan on wetland habitats and wildlife are unclear, again due mainly to inadequate base data. If there is any lowering of water tables arising from compartmentalisation or other aspects of the Plan, the extent of some wetlands could be severely reduced and others might dry up altogether. There is serious concern that the demand for land will result in further encroachment into wetlands. The possibility of an adverse impact on wildlife is acknowledged but given low priority. Yet, amphibians, some mammals, reptiles and birds would be seriously affected by the habitat loss. Embankments may severe water channel links between rivers and wetlands, affecting the migration of fish, shrimps, other fauna and micro-organisms and altering the ecological balance. New cropping patterns with increased applications of pesticides may result in increased hazard to wildlife. Inland fisheries could be seriously affected.

Special attention to these issues would have been an important addition to the supporting studies. If unforeseen damage to wetlands and wildlife is to be avoided, it is vital that baseline studies be carried out on wetland flora and fauna and into the life histories of important food fish and shrimps. According to (IUCN 1989), the Chalan *Beel*, a series of depressions in the lower Atrai basin, has already been ruined as a result of flood control, drainage and irrigation projects. However, it is difficult to isolate the causative factors involved in *beel* destruction. This subject is, therefore, in need of urgent research.

Fish

Fishing supplies Bangladeshis with almost 80 per cent of their animal protein. The fish are abundant in the rivers, canals and *beels* (flood plain depressions). With the rise of monsoon floods, recently hatched fish and shrimps, born in the rivers and estuaries, migrate into the flood plains where they feed and grow. As the floods recede, they return to rivers and permanent *beels* to breed. This easy migration and the breeding cycle could be prevented by the construction of embankments. It is proposed to incorporate 'fish passes', but it is far from certain (mainly due to a lack of knowledge about the basic life histories of local food fish) that these will guarantee the security of the migration on which millions of people depend for their fishing.

Public Participation

It is now widely accepted that sustainable development requires the active involvement of the local communities in development projects. The UNDP study remarks that *"past experience with people's participation in the operation and maintenance of flood control, drainage and irrigation projects has been rather disappointing"* and concludes that the reason for this was the *"technocratic way in which [flood control, drainage and irrigation] projects were designed and executed: people were not involved at any stage in the project cycle"* (UNDP 1989). Despite this and although the Action Plan accepts the need to involve beneficiaries, particularly, in the compartmentalisation pilot project (component 20), the extent to which local communities and potential beneficiaries have been consulted in the development of the Action Plan or to which they will be involved in project implementation or monitoring is not at all clear. It has to be concluded that there has been little, if any, such consultation and there has to be doubt that the Plan adequately represents the genuine needs and aspirations of rural communities. Some would argue that it merely represents a political response to the clamour for flood protection from wealthier, influential, urban-based groups.

People of the Meander Belt and *Char* Lands

The construction of embankments will contain waters which would otherwise have flooded over adjacent flood plains. As a result, a great many people who presently live in the active meander belts along the main rivers

and on *char* lands (temporary islands in river channels) will be exposed to increased risk from flooding. The construction of submersible embankments may help in some cases. The Plan fails accurately to account for the number likely to be affected. Dispossession for land acquisition purposes is likely to lead to an increase in the number of landless people, although this will still be small as a percentage of the overall problem of landlessness. The matter of compensation for those dispossessed and the issue of where such people are to be relocated is extremely important and will be considered under one of the socio-economic studies. (component 15).

Construction, Operation and Maintenance of Embankments and Compartments

Bangladesh has a shortage of building materials. Rock and gravel supplies are scarce. Neverthless, such materials will be required for the construction of control devices in the embankments. These and heavy equipment will need to be imported to the construction sites. The increased traffic using heavy vehicles will increase the likelihood of accidents, damage to tracks, roads and fields and localised oil-petrol pollution, etc. In addition, earth for the construction of embankments will have to be acquired locally. It might legitimately be assumed that this will be taken from lands occupied by the poorest, resulting in their further impoverishment. The Plan appears to give no consideration to these issues,but clearly they need to be seriously addressed.

In the case of the construction of diversion canals, a large number of people will be dispersed and will require relocation and compensation. The Plan appears to ignore these factors.

Environmental security within the planned compartments will be very dependent on sound management and operation. But according to the Plan, a higher level of management than that so far achieved in Bangladesh will be required. There must be some concern whether required improvements can be achieved. There is a real need for training, particularly, with respect to the coordination of controlled flooding.

Himalayan Deforestation and Floods: Another Environmental Myth

Deforestation in the Himalayas has been cited by some as the root cause of disastrous abnormal floods in Bangladesh. However, this cause-and-effect

linkage is not proven. According to (Ives and Messerlie 1989), there is no published evidence which indicates recent increases of sediment load or in the magnitude of floods on the Ganges-Brahmaputra flood plains. They make the point that deforestation is not a new phenomenon but has been proceeding for centuries. There is no doubt that a significant part of the high erosion and run-off rates in the Himalayas is mainly related to natural processes since the area is an active seismic zone.

Nevertheless, there are serious problems of forest degradation and soil erosion in the hill areas of Bangladesh which contribute to local flash floods, particularly, in the Sylhet region in the north-east. The Action Plan is not specific about measures to control deforestation and soil erosion.

Conclusion

Seasonal floods in Bangladesh are a natural phenomenon to which rural communities and farming practices are well adapted. But 'abnormal' floods do cause death, disaster and misery. The international community has pledged to help Bangladesh work towards alleviating this problem. None of the options for flood control so far suggested, including those advocating major structural interventions, offer guaranteed solutions and there are many environmental, engineering, social and other uncertainities with all of them. The Action Plan, in opting for a staged approach, appears to represent a sensible compromise between the extremes of extensive physical intervention and minimal intervention, with improved emergency planning, flood warning and services. It can probably be argued that amongst those options open to the country, including that of doing nothing, the Action Plan seems to offer the least objectionable course of action.

Nevertheless, the Action Plan has laid insufficient emphasis on the longer term uncertainities. All observers acknowledge that there is a dearth of environmental baseline data. Without this, predictions of the impact of the Plan's components are impossible. There is an obvious need to gather the required data and to establish monitoring facilities, yet the Plan does not provide for this. It seems obvious that this work requires to be added to the remit of component 16.

These problems and requirements were known at the London conference, (December 1989), yet no decision was made to take appropriate action. Environmental studies have already commenced on a fragmented rather than

integrated basis and seem likely to be undertaken in insufficient detail and duration to provide reliable impact assessments. It is difficult to be other than sceptical about their capacity to significantly influence the construction of embankments and other infrastructure. Despite the lack of baseline data, a number of possible serious negative environmental impacts can be predicted and have been discussed in this paper. In particular, a serious pollution problem may be in the making.

The concept of the Action Plan, like other major Environmental Action Plans (EAPs), is for coordinated multi-donor financial support and action within an integrated programme. Other EAPs have experienced the difficulty of achieving satisfactory coordination of fragmented donor project activities. There is already evidence of difficulties with coordination and phasing within the Action Plan, particularly, with respect to the environmental and regional studies. Active and professional coordination is absolutely vital. The consequences for the beleaguered people of Bangladesh of ignoring this problem could be catastrophic.

It could be argued that in order to take account of seasonal variability and long-term environmental effects, detailed environmental studies over a period of years should be undertaken before any major action of the kind envisaged by the Action Plan is implemented. Given the severity of the flood problem and the need to feed the rapidly growing population, this is not an option likely to be acceptable to the government of Bangladesh. However, it is imperative that those responsible for coordinating and implementing the components of the Action Plan and all donor agencies involved in financing or undertaking studies, ensure that they are fully conversant with the environmental issues and the measures being taken to address them and satisfy themselves that these are adequate. The Action Plan document itself provides very little discussion of the problems. A useful early product of the environment study (component 16) would be a report providing a thorough analysis of the issues which could be used as a public discussion document.

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CHAPTER TWENTY

THE IMPACT OF SHRIMP CULTURE ON THE COASTAL ENVIRONMENT

Atiur Rahman

Introduction

While the environment analysts and practitioners have been successful to some extent in raising consciousness of environmental crisis on two fronts (a) wasteful, polluting, resource intensive consumption patterns of the rich and (b) environmentally destructive practices of the very poor (Ekins 1992). They have, however, not sharply focused on another front i.e. the cost of development which is again closely related to both 'a' and 'b'. Indeed, a number of development initiatives have had disastrous consequences on environment in many of the aid recipient countries. A development project, not sensitive to environmental consequences, can have a number of negative impacts on the society and economy:

- It may take resources away from the poor, who were probably using them more effectively and sustainably.
- It may give more power to the rich, who may exploit the resources for their commercial interests unsustainably.
- It may encroach upon the rights of the poor to common property resources and thus deny them the benefits of expenditure saving incomes.

The present paper looks into the environmental impact of an aid initiated development project on the fisheries sector. The IDA financed shrimp culture project, though having huge potential for raising export earnings in foreign exchange, can have negative impacts on a number of fronts, closely in line with the ones already outlined above, if enough precautions are not taken to preserve the ecological balance.

The paper itself is divided into 6 Sections. Besides introduction, Section 1 gives a background of the development intervention and hypotheses and its possible negative consequences on the ecology and society. Section 2 focuses on the conceptual framework of understanding the interrelationship between development and environment. Section 3 highlights the methodology of the empirical part of the study. Section 4 summarizes the findings of the empirical enquiry conducted for the purpose. The final section concludes the paper.

Perspective

Bangladesh has been gradually emerging as an important producer of cultured shrimp and in the process, the fisheries sector has been contributing substantially to GDP. The contribution of this sector to GDP is 6 per cent compared to only 1 per cent in India (Aquatics Farm Ltd. 1989). Shrimp accounts for more than 80 per cent of sea-food exports from Bangladesh, which made a quantum jump from $19 million in 1977/78 to $140 million in 1987/88 (Aquatics Farm Ltd. 1989).

Bangladesh has some natural advantages in shrimp cultivation. The large delta created by the merging of the Ganga and Jamuna rivers, encompasses an area of 2.5 million hectares of coastal tidal land, much of which is ideal for the culture of tropical shrimp. In addition, there are large areas of coastal land suitable for brackish water aquaculture. The country also possesses one of the world's largest resources of wild *Penaeus monodon* shrimp fry (Aquatics Farm Ltd. 1989). These abundant water, land and fry resources place Bangladesh in a unique position to produce cultured shrimp at production cost, as low as anywhere in the world.

Despite these advantages, the average yield of shrimp has not been improving significantly. The yield per hectare was 169 kg. in 1986-87. Even today, the yield has not changed much. It has been emphasised by experts that better techniques for excluding other fishes from pond and

proper care of nursing fry have the potential of increasing yields up to 250-300 kg./ha. without major capital improvements or additional feed.

The Bangladesh Government is apparently well aware of the potentials of shrimp farming. Supported by the World Bank and UNDP, a separate project on shrimp culture has been in operation for some years and has been engaged in infrastructure development and organization of the shrimp farmers. Despite huge damages to some of the infrastructures during the 1991 devastating cyclone, the project is still on and contributing to shrimp farming. It is generally claimed that shrimp farming may have made 'partial improvement' in the economy of Bangladesh by improving shrimp production without reducing paddy or salt production in the coastal belt. This is perhaps true where the shrimp farming has been responsive to the demand for timely release of the land for paddy or salt cultivation. But in most cases, the shrimp farmers, either outsiders or powerful local elites, have not responded positively to meeting this demand. The net result has been quite disturbing. The indiscriminate intrusion of saline water into others' paddy fields and the exclusion of local shrimp farmers from the production processes have serious implication for the local ecology. Excessive salinity has not only led to shrinkage of common grazing ground for the livestock and poultry, many of the sensitive trees have also died. The outsiders have also imported migrant labourers from their own localities, perhaps for good reasons from their own perspectives. But this has laid off local labourers. The economic hardship of the local labouring class has thus intensified. Unprecedented social tensions have been unleashed. The state at the local level, especially police, has often been aiding the powerful groups for obvious reasons. So shrimp culture has led to degradation of environment, both physical and social, at a scale which deserves serious investigation. To place some of these facts in a proper analytical perspective, we may touch upon some interrelated conceptual issues.

Conceptual Issues

In order to get a comprehensive understanding of the interlinkage between development and environment, we will concentrate here on issues like sustainable livelihood, security and sustainable development. We shall then relate these ideas to the issue of environment.

Sustainable Livelihood Security

Normal development thinking has been preoccupied with *"things rather than people, the rich rather than the poor, men rather than women and numbers rather then qualities... Poor rural children, women and men have been treated as residual not primary, as terminal problems not starting points"* (Chambers 1987).

The Brundtland Commission Report (1987) makes an attempt to reverse this thinking and questions the relevance of the analysis and policies which tend to marginalize the poor. Instead, it recommends that the rural poor should get the priority it deserves. It presents this theme by developing a very useful concept called 'sustainable livelihood security'.

> "Livelihood is defined as adequate stocks and flows of food and cash to meet basic needs. Security refers to secure ownership of, or access to, resources and income-earning activities, including reserves and assets to offset risk, ease shocks and meet contingencies. Sustainable refers to the maintenance or enhancement of resource productivity on a long-term basis. A household may be enabled to gain sustainable livelihood security in many ways—through ownership of land, livestock or trees; rights to grazing, fishing, hunting or gathering; through stable employment with adequate remuneration; or through varied repertoires of activities."

There are moral and practical imperatives for 'emphasising sustainable livelihood.' It is moral because deprivation of such a magnitude is simply not acceptable. It is practical because we have a finite world. Pressure on resources is already very high. The livelihoods are in crises not only because of increasing rural population but also as a result of the acute concentration of the ownership of resources.

> "Poor people respond to this through intensification of agriculture and diversification of remunerative activities, through greater exploitation of remaining common property resources (CPRs), and through migration" (Chambers 1987).

It should be noted here that most of the developing countries' agriculture is resource-poor, rainfed, diverse, complex and vulnerable to natural calamities. Both rich and poor exploit lands and forests but for different reasons. The former does it for commercial interests, while the latter does it out of desperation. Deforestation, degradation of fragile soil, overgrazing,

erosion, and desertification are effects of actions of both the rich and poor. But the poor are unilaterally blamed. In fact, *"they are often victims in the scramble to exploit public and common resources in which the rich and powerful get in first"* (Chambers 1987).

While arguing for reorienting the conventional wisdom on the role of poor in the context of environment and development, Chambers asks for reducing vulnerability of the poor and seeks some solution for them.

> "The case for making sustainable livelihood security central for environment and development strategies is reinforced by the need to offset such pressures on resources both from the commercial and rich and from the poor. More and better sustainable livelihoods in areas of high potential can reduce pressures elsewhere from out-migration by the poor. But more important, and less well recognised, sustainable livelihoods in those resource-poor and forest areas are ecological and political safeguards against pillage and degradation by commercial interests and the rich. Contrary to popular professional prejudice, there is mounting evidence that when poor people have secure rights and adequate stocks of assets to deal with contingencies, they tend to take a long view, holding on tenaciously to land, protecting and saving trees, and seeking to provide for their children. In this respect, their time perspective is longer than that of commercial interests concerned with early profits from capital, or of conventional development projects concerned with internal rates of return. Secure tenure and rights to resources and adequate livelihoods are prerequisites for good husbandry and sustainable management. Moreover, sustainable livelihood security is a precondition for a stable human population in the long-term, for only when livelihoods are secure does it become rational for poor people to limit family size. Enabling poor people to gain secure and sustainable livelihoods in resource-poor and forest areas is, thus, the surest protection for the environment. The poor are not the problem; they are the solution" (Chambers 1987).

The crucial point is that when people have secure and permanent rights, they wish to and can afford to take the long-term view. By taking such a view, people tend to protect, conserve and enhance resources.

When rights are secure and poor people are not desperately poor, they often show extraordinary sacrifice and tenacity in holding onto assets. Where they own trees, they are often among the last item to be sold off in distress. The tragedy is that so many who depend upon forests are so insecure, or

their rights are so uncertain, that it makes no sense for them to take the long-term view. The challenge, and opportunity, is to establish and assure their rights and access and to secure their livelihoods, so that it makes sense to them to take the long view and to protect and enhance their environment (Chambers 1989).

This view broadly corresponds to the concept of sustainable development.

Sustainable Development

The concept of Sustainable Development also takes a longer time dimension, as it is supposed to achieve lasting satisfaction of human needs and improvement of the quality of life (Allen 1980). Goodland and Ledoc (1987) go a step further and bring in explicitly the issue of futurity. According to them:

> "Sustainable development is (here) defined as a pattern of social and structural economic transformation (i.e. development) which optimizes the economic and societal benefits available in the present, without jeopardizing the likely potential for similar benefits in the future"

The issue of perpetuity of economic well-being continually for many human generations is crucial in their framework. In other words, they argue for use of renewable resources in a manner so that their usefulness does not diminish for future generations.

Markandya and Pearce (1988) talk of sustainable development in the context of natural resources e.g. trees, soil, soil quality and water (excluding exhaustibles) and environments and emphasize that *"the use of these inputs to the development process should be sustainable through time."*

Pearce, Barbier and Markandya (1988) identify a situation of sustainable development in which development vector (with elements like real per capita income, health and nutritional status, education, fairer income distribution and basic freedom) should increase monotonically over time. To them, a necessary condition for sustainable development is *'constancy of the natural capital stock'*. That means the stock *of 'natural resources such as soil and soil quality, ground surface waters and their quality, land biomass, water biomass and the waste assimilation capacity of receiving environment'* have to experience non-negative changes.

The definitions of sustainable development given so far, may appear economical and an emphasis on social dimensions may be warranted, especially, if it is to be applied in a Third World country's context. Barbier (1987), does, reflect that concern when he says:

> "the primary objective is reducing the absolute poverty of the world's poor through providing lasting and secure livelihoods that minimize resource depletion, environmental degradation, cultural disruption and social instability".

It is in this context that (Chambers 1987) tackles the concept of sustainable development by *'putting poor rural people first'*. Other complementary elements of such a development are: *'learning process approach', 'secure rights and gains for the poor', 'sustainability through self-help'*, etc.

So the concept of sustainable development can be abstracted as follows.

- It involves a substantially increased emphasis on the value of natural and cultural environment.
- It refers to a concern which may be short to medium term (say 5 to 10 years) horizon within which a government plans or a long-term future to be inherited by the dependents.
- It emphasises both intra-generational and inter-generational equity.

Our discussions so far. on both sustainable livelihoods, security and sustainable development hover around three key concepts: environment, futurity and equity. These are, however, not mutually exclusive. On the contrary, they are mutually reinforcing.

Environment

The issue of protection and enhancement of environment has been noted a number of times in the above paragraphs. The term environment, though used frequently and casually, deserves to be defined and elaborated. The dictionary definition of environment entails *"the aggregate of all the external conditions affecting the life and development of an organism"* (Neilson 1953). Encyclopedia of Social Sciences also views environment *"as sum of the factors that act on living plants and animals from outside"* (Sills 1972). These definitions focus mainly on surroundings, conditions and influences.

One may reorganize these definitions into a more plausible one: environment is the totality of natural external conditions and influences that affect the way things/beings live and develop.

From an economist's point of view, environment is seen, *"as an asset or a kind of non-reproducible capital good that produces a stream of various services for man. These services are tangible (such as flows of water or minerals), or functional (such as the removal, dispersion, storage, and degradation of wastes or residuals), or intangible (such as a scenic view)... these environmental services will be those that are affected by the production and consumption activities of man and by ways in which he disposes of his residuals"* (Freeman *et al.* 1973).

An economist usually talks in terms of preference for a good/service which yields most satisfaction or welfare. An improvement in welfare is equated to an economic improvement if it increases social welfare.

But preferences for the environment, which show up as gains in welfare to human beings, need to be measured. A benefit is any gain in welfare. A cost is any loss in welfare. So an economist is concerned with measurement of the benefits from improvements in or the costs of reductions in environmental quality.

Environment has a direct bearing on the issue of vulnerability, which is a more pertinent concept for understanding underdevelopment. (Rahman 1989b). A degraded environment can be a cause of concern for those who derive a substantial source of livelihood rather than cash income from the surroundings. Chambers (1986) tackles this point very ably:

> "In three respects, this emphasis on income fits badly with past realities. In the first place, a high proportion of the 'income' of poor rural people is often in kind, for subsistence—especially crops and livestock which they grow or herd themselves. Economists have tried to accommodate this by placing a cash value on subsistence flows. Second, the method fits best with a regular wage or salary income which does not vary round the year—a characteristic of urban, industrial, formal sector employment which contrasts with the variations of rural incomes year by year, and within years, season by season.
>
> Third, the income definition of deprivation overlooks vulnerability to contingencies. This is easily neglected by first, professionals. Shielded by state social security, by savings or by other means, they underestimate the importance of contingencies for others less fortunate. But for the rural poor,

the position is radically different. They are vulnerable to many sudden unforeseeable needs, which may be great or small, or needs which are foreseeable but large. These include social conventions, such as dowry, bridewealth, weddings, funerals and other ceremonies; disasters, such as floods, fires, the collapse of a hut, theft of animals or tools, the death of an animal, a bad year for crops; physical incapacity, such as sickness, accidents, the child-bearing sequence; unproductive expenditure, such as children's education, bribes or investments, where these do not pay off; and exploitation by the rich and powerful.

In many places. the costs of such contingencies have risen while the social supports which in the past helped the poor to meet them have weakened. Health treatment which once was cheap, through traditional remedies, increasingly opens up expensive options which impoverish those whose relatives are seriously sick. For those who are peripheral, the costs of transport add to the problems. While costs of contingencies have been rising, the mutual supports of patrons, the extended family, neighbours, and the community have generally been weakening."

Against this backdrop, an appropriate concern will be to observe whether a family has the capacity to meet contingencies in order to grasp its magnitude of deprivation. This forces us to define environment in terms which go beyond material well being. The sources of contingencies can be both physical and social. Hence, environment has to be seen as aggregate of natural, physical, biological and socio-cultural conditions that are subject to human alterations. It encompasses all living organisms and their interactions with society, particularly, humans and their future generations.

Given these conceptual understandings, we would like to know whether a development intervention like the Shrimp Culture Project in Bangladesh has been enhancing or reducing the security of livelihood for majority of the population living in the coastal belt. In other words, whether due to the presence of the project:

- Access to private resources, in particular, land, livestock, trees etc. is increasing or declining for the majority?
- Access to common property resources by them, (ecological resources like common grazing land water bodies, forests etc.) has been expanding or shrinking?

- Personal security has been under greater or lesser threat due to violence perpetuated by a few powerful persons, who are the net beneficiaries of development interests?
- The traditional safety net for the poor (in the form of networking, solidarity, community support) is rupturing or strengthening since the initiation of the project?

Methodology

The hypotheses already derived are put to test utilizing primary level data generated from 238 shrimp farms chosen purposively from Khulna and Cox's Bazar coastal areas. Of them, 116 farms belonged to a IDA supported project area. The others are from controlled areas, not yet intervened by any state sponsored development initiative. The data were collected during March–May 1990. Both questionnaire and participant observation methods were used while collecting information. A few case studies have also been collected to supplement the conventional information base.

The study areas are shown in Table 1.

Table 1

Study Areas

Khulna		Cox's Bazar	
Project Area	Control Area	Project Area	Control Area
Polder 20 (Paikgacha)	Polder 23 (Paikgacha)	Polder 66/3	–
Polder 21/1 (Paikgacha)	Rampal	Polder 66/4	Khutakhali
		Polder 70	Bodarkhali
		Rampur	–

As seen in Table 2, shrimp farming has been concentrated among the larger landowners. The concentration is lesser in the SCP area compared to the control areas.

While a quarter of the households in the project area own more than ten acres of shrimp land, the proportion of such farmers is one-third in the non-project areas. Similarly 28 per cent of farm households in the project area are smaller in size owning less than 2.5 acres of land. In the control area, such farm households constitute only 12 per cent of the total households. In Khulna, the proportion of this group is only 3 per cent in the control area. The proportion of them is higher in the project area.

Table 2

Land Ownership amongst Farmers

		Small Farmers		Large Farmers	
		% HH	% of land owned	% HH	% of land owned
Khulna	Polder	33	70	21	57
	Control	32	41	34	65
Cox's Bazar	Polder	22	41	32	72
	Control	12	31	43	80

Results

Control Over Land

The landownership pattern in both project and control areas is highly skewed. As seen in Table 2, the large farmers own most of the land in the coastal belt. The concentration is slightly higher in the project areas. However, land ownership alone does not tell the full story. We need to look into the pattern of land use by different groups of farmers as well.

Use of Land

The poor cannot put all of their land for shrimp culture due to lack of capital. They are forced to rent out their pieces of land to large farmers so that they can have bigger farms.

Since the introduction of shrimp farming, the price of land has gone up and a new lease system has developed, giving rise to a high incidence of land disputes and violence.

The leaseholders, mostly outsiders, are the source of these contradictions. In Rampur, Cox's Bazar, the government leased out 1990 ha of *Khas* (government owned) land in 468 plots, to 371 individuals/organizations for shrimp culture. Of them, 336 plots have been leased to 'so-called' shrimp farmers (who are mostly urban residents), individually. They have, however, subleased their plots to others, who in turn have leased them out to other groups. As a result, a chain of tenural heirarchy has developed, defeating the original objectives.

Indeed, shrimp cultivation has revealed contradictions that are beyond the control of local people. Their traditional command over this principal private resource (i.e., land) has been seriously threatened. A kind of 'enclave economy' has developed in the coastal belt, marginalizing poorer landholders in the process.

In Khulna, land is primarily used for paddy cultivation. The existing shrimp farmers, in most cases being outsiders, do not always care for the interests of the local paddy farmers. The harvesting of shrimp is often deliberately delayed by the outsiders. The saline water is not allowed to be drained off the field till the shrimp is harvested. On the contrary, there may be addition of saline water from upstream. This does not, however, necessarily improve the yield of shrimp significantly. But the delayed harvest of shrimp can cause late transplantation of *aman* seedlings. If the transplantation is done later than mid-August, the paddy yield may even be halved (Table 3).

In the Khulna project and control areas, 71 and 92 per cent of respondents, respectively, informed that paddy cultivators have been facing problems due to late shrimp harvest. That means the adverse impact of shrimp culture on paddy cultivation is more severe in non-project areas than the project area. But the impact is overall negative in both areas.

There is another negative economic impact of shrimp farming. Preparation of seedling beds is not always possible due to prolonged stocking of saline water. This problem is, particularly, severe for those who have all their cultivable lands within the shrimp farming zone. As a result, they need to spend more time and money for collection of seedlings from sources outside their locality at a higher cost.

In Khulna, only 30 to 25 per cent of respondents from project and control areas can raise the seedling beds in the areas in which they live in. Others have to collect them from outside at higher costs and greater hardship.

Table 3

Change in Yield of Paddy in Khulna (1986 to 1989)

	Project Area			Control Area		
Land Groups	1986	1989	% Change	1986	1989	% Change
0.50 – 2.49	*26	19	-26.92	36	21	-41.67
2.50 – 4.99	27	18	-33.33	33	21	-36.37
5.00 – 9.99	24	16	-33.33	32	18	-43.75
10.00 +	26	18	-25.00	33	19	-42.43
	26	18	-30.77	33	19	-42.43

* Production in maunds per acre in shrimp land.

In Cox's Bazar, the problems are of a lesser magnitude. Here land is primarily used for salt cultivation and shrimp is only a supplementary produce.

However, there have also arisen some problems here due to shrimp cultivation. Earlier, the land used to be kept fallow for a period just before initiation of salt cultivation. But due to the pressure of shrimp cultivation, this lead time is no more available to the local farmers.

Besides earlier, the unrefined salt used to be stored in the field which could be sold at a better price later on. But now, due to shrimp cultivation, either the raw salt has to be sold immediately after the harvest, at a lower price or it may be stored with a risk of depletion, by about 20 per cent of the stock (compared to 10 per cent earlier). The standing water in shrimp farms causes this loss of stock.

Control Over Livestock

Livestock, especially cows and goats are important private resources which play a significant role in overcoming vulnerabilities of the marginal households.

Shrimp culture has been causing some problems in the raising of these animals. Perception of the problem, however, varies in the two areas because:

- Khulna is primarily a paddy producing area whereas Cox's Bazar is a salt producing zone.
- Drought animals are in greater demand in Khulna compared to Cox's Bazar.
- Saline water-logged shrimp fields near residential plots in Khulna makes raising of livestock extremely difficult. But the problem is not so severe in Cox's Bazar where shrimp farms are normally far away from the homesteads.

Introduction of shrimp culture on the one hand, has deprived the local people of the right of access to common grazing land which has now been leased out to shrimp farmers coming from outside. On the other hand, shrimp farmers will not allow cattle to pass over internal dykes built for shrimp farming.

As a result, the local people have been forced to keep their cattle in houses of relatives in neighbouring villages. The consequences have been:

- Increase in cost: a rental charge of Tk. 25 per animal per month has to paid by the owner just to keep the animal in the cowshed of neighbours.
- Loss in quality of animal and yield: Loss of common grazing grounds has led to scarcity of fodder and grass for animals which has resulted in deterioration in health of the animals. Obviously, the yield of milk has also declined.
- Loss of income: cow dung and milk are normally retained by the owners of cowsheds and thus the expenditure-saving income of the affected farmers has been reduced.

From 1986 to 1989, total production of cows and buffalos in Khulna has declined by 47 per cent and yield by 25 per cent (Table 4).

In Cox's Bazar, perception of the problem is slightly less for factors already mentioned. But in control areas of Cox's Bazar, where people alternate shrimp production with paddy farming, the nature of the problem is almost similar to that in Khulna.

Table 4

Production of Cows and Buffaloes (1986 to 1989)

	Cox's Bazar		Khulna	
Land owning groups	Polder	Control	Polder	Control
0.50 – 2.49	-22.22	-21.43	-45.19	-100.00
2.50 – 4.99	+9.09	-80.95	-48.19	-15.63
5.00 – 9.99	+36.84	-50.00	-48.72	-43.08
10.00 +	+11.90	-70.56	-45.13	-54.73
	+10.49	-65.40	-46.86	-47.05

Ownership of Poultry

Ownership of poultry birds is very important for the poorer households as it can provide a small but regular income for them. For the poor, it is not only income, but the stability of income throughout the year which is more crucial. It has become very difficult to raise ducks in the shrimp farming area, as strong restrictions have been imposed by shrimp farmers on their movements, so that they cannot catch fish from the farms. Raising of ducks has thus been drastically reduced. Raising chicken is not easy either. The mortality of poultry is also high in areas where salinity is very high. We have noted that from 1986 to 1989, both in project and control areas, production of poultry has declined by 36 per cent (Table 5). The situation in Cox's Bazar is better, owing to the fact that the shrimp farms are far away from the homesteads.

Ownership of Trees

Trees can contribute significantly for livelihood security of the poor. They provide assets in addition to biomass. Trees provide subsistence and income in many ways. Non-timber forests and tree products include edible fruits, nuts, roots and condiments. Fodder and firewood are also provided by trees. Thus trees can be a very stable source of income to tide over seasonal hardships, especially during, slack seasons and thus reduce the need to migrate out of their villages. During bad times, tree owners can sell them

off. People may also use trees as 'saving banks' and as means to meet contingencies or to settle debts (Chambers *et al.* 1989).

Table 5

Production of Poultry (1986 to 1989)

	Cox's Bazar		Khulna	
Land owning groups	Polder	Control	Polder	Control
0.50 – 2.49	+8.26	+26.00	–38.69	–
2.50 – 4.99	+42.39	–5.50	–23.10	–24.00
5.00 – 9.99	+167.61	–14.50	–40.30	–17.60
10.00 +	+54.04	–11.90	–37.20	–46.80
	+62.41	–2.00	–36.13	–36.20

Trees have, thus, a potential to reduce vulnerability and provide both cash and collateral generating assets for the poor. As can be seen from Table 6, there has been a general decline in the per household ownership of trees like coconut, betel nut and mango in both Khulna and Cox's Bazar. However, the decline has been much sharper in the project area compared to the control area.

We will now look into implications of shrimp farming on tree production. Before introduction of large scale cultivation of shrimp in Cox's Bazar, a major portion of the coastal belt (e.g. Sundarban in Chakoria) was deep mangrove forest. Sporadic green spots of trees could also be seen. The lands containing such green bushes used to be left fallow. Herds of buffaloes and cows could be seen grazing in these spots. As soon as shrimp cultivation became commercialized, all these green spots were wiped out. Even the large forest strips in Rampur (Sundarban) have been erased from the landscape by enterprising shrimp cultivators (Rahman 1989a). Currently, a big polder of about 1900 ha is being developed as a shrimp farming zone with support from IDA. Both local people and livestock have been deprived of the natural protection which these forests used to provide them. The environmental quality of the area has been compromised, while promoting shrimp farming which has a high export potential.

Table 6

Changes in Farm Size and Household Ownership of Trees

	0.50–2.49			2.50–4.99			5.00–9.99			10.00		
	Coconut	Nut	Mango Jack-fruit	Coconut	Nut	Mango Jack-fruit	Coconut	Nut	Mango Jack-fruit	Coconut	Nut	Mango Jack-fruit
Khulna												
Control	0.43	-50.00	-64.70	-40.40	-66.17	-54.80	-31.68	-55.10	-50.00	-31.16	-52.04	-50.00
Project	-30.16	-47.62	-36.10	-32.99	-60.93	-97.10	-23.91	-49.53	-104.40	-34.88	-35.97	-44.90
Cox's Bazar												
Control	-18.18	-31.58	4.60	-17.46	-25.51	- 2.00	-25.00	-18.68	- 2.10	-11.98	-18.79	- 1.30
Project	-11.11	- 5.56	-11.76	-21.57	-17.58	- 2.40	- 6.67	-21.05	15.00	-16.07	-11.79	- 1.50

Only a few have gained from this latest economic pursuit. The losers are, however, many.

Access to Common Property Resources

Besides loss of private resources, local people have suffered a loss in control over common property resources like common grazing ground, common water bodies, common forests etc. The loss of access to such common to property means net loss for its user. The loss may take forms of:

- Loss of livestock when a common grazing land is turned into private property.
- Loss of time and energy which in turn is loss of cash when nearby water resources are contaminated with salinity, hence longer travel time is needed to fetch household and drinking water.
- Loss in cash due to shortage of firewood when a common forest becomes inaccessible.

Access to Water Bodies

Since the introduction of shrimp culture, catching of non-shrimp fish has become difficult. Most of these fishes are considered as predators by shrimp farmers. Farmers screen out the predators while stocking shrimp fries. A huge number of non-shrimp fries get killed prematurely while collecting shrimp fries from open water bodies. Apart from that, a number of canals earlier available for fishing, by the poor, have now been turned into shrimp ponds and people are not allowed to fish in them. Fishing by night has virtually been eliminated in the coastal belt.

In short, there has been a negative impact on the production of non-shrimp fishes due to shrimp cultivation and those dependent on fishing for subsistence have been forced into deprivation.

Insecurity and Social Tensions

Shrimp culture has also intensified social contradictions in an otherwise tranquil village community. A large portion of peasants have been forced out of their traditional sources of income, while most shrimp farmers do not

always employ local landless persons on their farms. They bring in their own loyal workers from outside. As a result, the poverty situation has worsened among the local poor.

Personal security of these local landless people is always at stake. Local people cannot even walk over the *bundh* (dykes) raised by shrimp producers. If they try to walk over the dykes, they are often assaulted physically. The security of women is under greater threat. Their honour and self-respect are often dashed to ground by the musclemen of the power elites. No organized protest is tolerated. Local police and administration in most cases, side with the emerging powerholders for reasons known to all. A number of disputes have already been reported where the poor agitators have been bodily harmed or even killed.

Cases of theft, gambling, wife-beating, drinking, rape, divorce have been increasing since the introduction of shrimp farming. These are indeed some dimensions of poverty which have been accelerating due to shrimp farming.

Rupture of Traditional Safety Net

Shrimp culture has brought with it, a number of vulnerabilities among the poor in the coastal area. Since the *gher* (i.e. shrimp field) owning outsiders do not belong to the community, they hardly feel for it. The outsiders distrust the local landless. An air of tension looms large. The traditional patron-client relationship among the local rich and the poor in the form of interlinkages of various exchange is being gradually ruptured. The poor are either migrating out of the area or forced to accept a demeaning life style.

Since shrimp cultivation became popular, significant proportion of the local people have not only become alienated from this profit-earning enterprise, but also have begun to face increased economic pressures for various other but related reasons:

- Shrimp farming requires development of dykes and planned water management. Individually, the local poor cannot organize shrimp production. They cannot lease land from others because of lack of capital. In most cases, they need to lease out their own pieces of land to outside leaseholders often at a nominal rent or no rent at all. The leaseholders cultivate land on their own ways and do not always harvest shrimp in time so that local farmers find it difficult to transplant paddy seedlings. A delayed transplantation causes lower yield of paddy.

- Shrimp cultivation has made it virtually impossible for the local farmers to raise livestock and ducks in the area. The shrimp farmers do not let cows to pass over the dykes, not to speak of grazing on them. Indeed local farmers send their cows out of the polder areas and rent space for them. They are also deprived of the cow dung which could be used as fuel at a time when there is virtually no firewood around.
- Since shrimp culture has become widespread, local households are facing difficulties in obtaining fuels for their domestic consumption. The leaves of trees and other conventional sources of fuel have dried up. The poorer households, especially, poor women have been severely affected by this squeeze on the ecological reserve.
- The opportunities for community fishing which used to exist earlier have also been squeezed since shrimp production began on a large scale. There were a number of *khas* river/canals where people used to fish round the year. But nowadays, all those water bodies have also been leased out. The tributary, Nara is a case in point. This has been leased to one of those who are one of the net beneficiaries of shrimp cultivation. There is general disenchantment among the local people against outside leaseholders who have been encroaching on their traditional means of livelihood.
- The leaseholders do not trust the local labourers and rather hire labourers from villages which are not within the polder. Unemployment being acute, this bias against local wage labourers has further fueled discontentment among them.

Not only the small peasants, but also the middle and rich landowners owning as much as 15 acres of land are not immune from exploitations by outsiders. A very powerful outsider has forcibly occupied more than 700 acres of land from local farmers in the Khulna area and has not been paying any rent to them. These farms are managed by hired musclemen of the powerful outsider and now the local people cannot even walk over the dykes raised over their own land. A number of cases have been reported to us where these musclemen maltreated local farmers for violating 'restrictions' imposed unilaterally by the outsiders. Even the ducks raised by local farmers are killed if they trespass the shrimp farms of the said 'godfathers'.

Case Studies

The following case studies further reveal the cost of shrimp culture in terms of loss of livelihood security to the local farmers.

Akhil Mistri (48)

Vill: Par-Madhukhali

Upazila: Paikgacha, Polder 20

Family size: 6

Land owned: 1.65 acres

% of land owned under shrimp farming: 100

Date of interview: 22 April 1990

"Even three years back when shrimp culture was not so popular, we could subsist on whatever we produced in our farm. But now, we need to buy almost everything from the market for our day to day living. Fruit trees are suddenly no more.

Before getting into shrimp cultivation, I had 8 cattle breeds including a milch cow. But now I have only 4 such animals, most of them being very weak. The milch cow is still there. But she does not yield much milk. Just two three years back, the same cow gave us plenty of milk.

Earlier, we could catch big fishes from the family pond. We could even distribute some of them to our kith and kin. But as saline water seeped into the pond, the water got contaminated. And that was the end of it. All fishes got killed. We cannot replace them now. The principal food items like fish and milk are now rare commodities here in the polder.

Trees have been the worst victims of intrusion of saline water. Even two years back, we had 16 coconut trees. Now as you can see, there are only four left. Their condition is not very well either. Fruit trees like coconut, nut, mango, jackfruit, *lichi*, etc are experiencing high rates of mortality.

So the availability of firewood has been drastically reduced. We buy firewood including dried cow dung from outside at a high cost. The supply of straws of paddy stalks has also been greatly reduced.

The raising of livestock is indeed a great problem. There is no land left for grazing. Except for a brief period, the animals have to be kept elsewhere You need to pay some charge for that. The quality of livestock is deteriorat-

ing. They are now weak and disease-prone. The goats too are in trouble. A kind of skin disease has become widespread. The goats are loosing hair. They often die. We have not seen this disease before the advent of shrimp culture in this area. I lost at least twelve of my goats during the last four months. Now I only have another six. I really do not know how long they will survive.

The *gher* owners, mostly outsiders are obstructing our traditional ways of survival. The poor people cannot catch fish in the government canals near a *gher*. They are challenged by the security guards of the *gher* owners. Even if we carry a net while walking by the gher, we are challenged. This hurts our self-respect. A kind of psychological distance has developed between the locals and the outsiders. If these mutual distrust continues to grow further, it may be difficult for us to live in the same locality".

Nimai Mondal (35)

Vill: Radha Nagar

Upazila: Paikgacha, Polder: 20

Family Size: 6

Total land owned: 5 acres

% of land owned under shrimp culture: 67

Education: Upto class nine

'*Hari*' (lease money) received: Tk. 800 per *bigha* (.33 acre).

Date of interview: 22 April 1990

"Fruit trees were abundant here when the shrimp cultivation was not in practice. *Rabi* crops were also plenty. But both trees and *rabi* crops have now vanished from the landscape. Firewood is not available now. Cow dung could have been used as a substitute. But cows are kept in far away places during most of the year. Those who keep cows also get the cow dung. So we need to buy cow dung from them. Hundred pieces of cow dung cost us Taka fifty to sixty. We buy our own cow dung. What a trick ! There is no place to raise the animals. The whole area is flooded with saline water. I had eleven cows. But now I have only eight, most of them are not healthy. The grass and fodder are rare in polders. So we need to spend a lot for feeding the cows. The milch cow now provides very little milk.

A number of social problems have cropped up. The younger people have become more commercial in their attitudes and values. They go for easy

money rather than concentrating on studies. They spend most of their time catching shrimp fries and harvesting shrimps. Some of them are involved in theft of shrimps. Recently a boy was caught red-handed while stealing shrimps in a *gher*. He studies in the local high school. Such moral degradation is a direct by-product of the shrimp culture".

Muhammad Rahmat Ali (40)

Vill: Hanirabad; Polder: 20

Family size: 6

Total land owned: 3.48 acres

% of land owned under shrimp cultivation: 86

Education: Illiterate

Date of interview: 24 April 1990

"The yield of paddy has certainly gone down. This year, I have produced five maunds of paddy per *bigha* (i.e. 200 kgs. per acre). The yield of paddy is even worse in the shrimp field of Wazed Mia, the most influential shrimp producer in the locality. The production of paddy is worse in lands where they put in lime.

I lost most of my date trees over the last two or three years, three mango trees, a number of coconut and banana trees over the years. Those which are still there, look very pale. They may die any time. If the shrimp cultivation continues like this, probably, you will hardly come across a tree.

The social environment is getting vitiated. The boys prefer to earn money from shrimp culture rather than going to school. They are also involved in petty theft and local violence. Influential outsiders have injected an element of mistrust and instability into the polder area. Local people feel insecure.

We need to use the embankments, bunds of canals for every day movement. But whenever we pass a *gher*, we are suspected of moving with some ulterior motive. This is indeed demeaning for most of us."

Conclusion

The empirical findings presented above, clearly demonstrate that the primary beneficiaries of shrimp culture in the coastal belt of Bangladesh have been the outsider leaseholders and a few of the local influentials. Their unplanned

intervention and lack of respect for the traditional ecological balance have not only created serious repercussions to the economic well-being of the poor in the locality, but a host of social contradictions have also been sharpened. The sponsors of organized shrimp farming have clearly seen the potential danger in unplanned shrimp farming in the coastal belt. So they have taken help from NGOs to conduct social engineering among the poor farmers so that environmental costs can be minimized. The NGO intervention has definitely helped reduce the costs to some extent. This is reflected in the varied nature of environmental consequences of shrimp farming in terms of livestock and poultry raising, tree production etc. in the project and non-project areas. But even then, the impact of this intervention remains negative.

There is a need for further appreciation of the interconnections between development initiative like shrimp culture and environmental degradation. The project initiators should have far wider concern for the likely impact of the project and take steps to remove anomalies in the leasing arrangements. It should also take a tougher attitude against those who are violating lease contracts and impose violence on the local people. Of course, this can happen only when the local state machine becomes more responsive to people's problems. But apparently, the state machinery has already been hired out by the monied leaseholders (outsiders) to protect them. The only option left is, therefore, organizing the rural poor. Only the organized poor can ask for their due share of development. The Shrimp Culture Project, though not that explicit, has an objective of organizing the real farmers and the poor. But they could not progress much in this field due to structural constraints. The project in any case has to constantly monitor the environmental consequences of shrimp farming. Also measures for afforestation on the dykes and social development programme for the poor have to be encouraged in order to affect some of those costs. The environmental lobbyists and groups also need to watch the impact of the project on the local environment.

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